Health and Welfare Canada
Santé et Bien-être social Canada

Shallow Wells and Precipitation Catchments Used to Supply Drinking Water in Canada

102-04686/

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Environmental Health Directorate
Health Protection Branch

Published by Authority of the
Minister of National Health and Welfare

Également disponible en français sous le titre
Puits peu profonds et systèmes de captage de précipitations utilisés pour l'approvisionnement en eau potable au Canada

Copies of this publication may be obtained from:
Communications Branch
Department of National Health and Welfare
19th Floor
Jeanne Mance Building
Ottawa, Ontario
K1A 0K9

© Minister of Supply and Services Canada 1991
Cat. H49-64/1991E
ISBN 0-662-18650-8

EHD-TR-148

This document was prepared under contract by R.L. Walker and Partners Consulting Engineers and by DGB Enviroconsultants.

The scientific authority for this contract was J.C. Méranger, M.Sc., of the Environmental Health Directorate, Department of National Health and Welfare, who provided guidance and direction in the preparation of this report.

The conclusions and recommendations contained herein represent the opinion of the contractors and do not necessarily constitute endorsement by the Department of National Health and Welfare.

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Summary

This report represents informed estimates on the extent of use and the location of shallow wells used for domestic purposes by Canadians. In its preparation, the latest available data has been used, i.e. the most recent Canadian population statistics for 1986. Of the estimated 6.9 million people in Canada who depend to some degree on groundwater through either municipal distribution systems, communal pumps or individual pumps for their domestic water requirements, it is estimated that over 1.6 million people are dependent on individual systems drawing their waters from 0.64 million shallow wells (shallow is defined in this report as being less than 15 metres in depth). Several thousand others have as their main source precipitation catchments of various kinds. Precipitation catchments, except for larger dugout programs supported by PFRA throughout the prairie provinces, are virtually unrecorded. Estimates of precipitation catchment use are dependent on the knowledge of local authorities. These estimates are only approximate because of the need to derive the estimates through the use of municipally supplied populations, and informed estimates provided by provincial and territorial officials. The database needed to perform the task of providing reliable values on the population use and distribution of these users on a national basis does not exist.

While some provinces are able to search computer databases to create printouts of analyses using different data fields and limits, others must still limit themselves to pre-established formats which, in many cases, are regionally based and have been developed specifically for the use of the well drilling industry.

The creation of a uniform national database would require close cooperation between provincial officials responsible for obtaining and collecting the data. This effort could be coordinated and guided by a respected and informed multi-disciplinary board composed of federal departments who would advise on the minimum required information to be collected, setting uniform systems of keywords, and establishing the various formats of information retrieval of the data contained in the provincial databases.

In terms of the broader purpose of Health and Welfare Canada which is to assess the risk to public health from acidic deposition affecting the quality of shallow groundwater sources, areas where shallow groundwater sources represent a dominant source of drinking water have been highlighted. Despite data limitations in defining the exact extent of shallow groundwater sources and use, the distribution of shallow groundwater use, as reported herein, could be correlated with existing data systems concerning the distribution of population, geology, soils and climatology.

Study areas for national type surveys could then be identified and specific contaminant surveys could be conducted to determine the impact of acidic deposition on groundwater drinking water supplies.

1. Introduction

1.1 Study Objectives and Process

Previous studies initiated by the Department of National Health and Welfare on national surveys of trace elements in Canadian drinking water supplies[1] and tap water consumption by the average Canadian[2] have been used to calculate the total daily uptake of trace elements from drinking water. More recently, an investigation was conducted to determine the potential sensitivity of drinking water supplies to acidic deposition[3] and a study was conducted within three areas of the Canadian Shield to investigate the possibility of mobilization of toxic elements into groundwater drinking water supplies[4]. At that time, it was decided to conduct a national study to estimate the number of Canadians relying on shallow wells and precipitation catchments for their daily drinking water needs since it was well realized that these types of water supplies would be more vulnerable to general environmental contamination and would also be the first affected by the mobilization of trace elements from soils and underlying overburden.

The objectives of this report are summarized as follows:

a) To update and reassess available data on shallow wells and precipitation catchments used for drinking water;

b) To estimate the number of people dependent on each of the sources throughout Canada; and

c) To recommend actions that need to be taken in order to obtain the necessary data so as to direct future studies on the vulnerability and geographic location of users of shallow wells and precipitation catchment systems.

A study plan was established to obtain data on the number of wells and their location, and through the use of Statistics Canada's 5-year census, identify areas throughout Canada which could be prioritized, taking into account both acidic precipitation data from Environment Canada as well as data on the buffering capacity of soils and bedrock available through other agencies, in order to direct future research activities of the Department. In early 1987, Health and Welfare Canada made initial contacts with key provincial, territorial and federal officials knowledgeable in the areas of various aspects of the study. Subsequently, the study was continued under contract and a final report was produced in March of 1987. After study of the report, a second contract was awarded to update estimates by taking into account newly published 1986 population census information and by obtaining updated information from people already contacted for the previous report.

The Pearse Inquiry on Federal Water Policy noted the lack of a national inventory of groundwater sources and that most aquifers used in Canada are small and relatively shallow[5]. Numerous submissions to that inquiry remarked on the lack of data and information on the state of groundwater in Canada. A review of groundwater use across Canada in 1981 indicated that groundwater was the source for 2.2 million people supplied by municipal water systems and 4.0 million people in rural areas[6]. This indicated that some 26% of Canadians were reliant on groundwater for their drinking water needs.

Since unconfined aquifers are directly fed from precipitation or runoff infiltration, they are more susceptible to contamination from various sources, including acid rain, than are confined aquifers. A well depth of 15 metres was selected by Health and Welfare as a rough proxy for vulnerability, thus focussing primarily on shallow wells. Relatively little information has been compiled on a national basis about the quality of groundwater used for domestic purposes. There is also a lack of information on the location and extent of aquifer use at a national level.

This study presents information obtained from water resources and health experts across the country. Provincial and territorial authorities provided most of the quantitative data presented in Section 2 of this report. Annex 4 lists the individuals who were contacted for information in the course of the initial phases and were recontacted for this update. References listed at the end of the report are noted throughout. Even though there are in all provinces and territories systems for recording data on drilled wells, each system is different. Most of the systems do not require the reporting of dug wells or precipitation catchments, nor do any require verifications of groundwater chemical quality. The voluminous but uncoordinated data precludes an accurate summary of the existing situation. Furthermore, issues concerning drinking water quality have hardly been addressed previously on a provincial or territorial basis for precipitation catchments and shallow wells; thus, a national perspective is very difficult to obtain.

Despite the lack of comprehensive data or the possibility of applying rigorous procedures for assessing the information systematically, this overview has been prepared from interpretations of the available data to provide estimates of the extent of dependence on shallow wells and precipitation catchments at provincial, territorial, and national levels.

1.2 Demographic Distribution of Population

The most recent comprehensive population figures are those from the 1986 census. In that year, Canada's population totalled 25.3 million, including 6.0 million people living in rural areas. Statistics Canada defines rural areas as those outside continuously built-up urban areas with a population of 1000 or more and a population density of 400 or more per square kilometre. For example, a suburban housing estate which has one home per 0.4 hectare (1.0 acre) and an average of 3.0 people per home would have a population density of 750 people per square kilometre and be defined as urban by Statistics Canada. According to this definition, the rural share of the population ranged from a low of 17.9% in Ontario to a high of 61.9% in Prince Edward Island. The national average places 23.5% of the population in rural areas, or one out of every four Canadians. Population data for 1986 are summarized in Table 1.1.

Population data are broken down between rural and urban for each of the 266 census divisions used by Statistics Canada. The Census Division Map shows these throughout the country and Annex 1 provides 1986 data on the urban and rural populations in all census divisions in each province and territory. Ontario and Quebec continue to be the most populous provinces, accounting for 36.0% and 25.8% of the total 1986 population respectively. Yukon and the Northwest Territories have the smallest shares of the overall population, accounting for 0.1% and 0.2% respectively.

Only a minority of the rural population in Canada are living on farms. Table 1.2 provides data on rural farm households and populations for each province and territory. In 1986, there were 246 640 rural farm households in all of Canada. They had a total population of some 0.9 million, accounting for only 3.5% of the national population and 14.9% of the rural population. The largest rural farm household populations were in the provinces of Ontario, Alberta, Saskatchewan and Quebec, in that order. These four provinces together accounted for 80.4% of the national rural farm population. On a national basis, the per capita percentage of rural farm versus total population was highest in Saskatchewan (16.0%), followed by Prince Edward Island (8.1%), Manitoba (8.0%), and Alberta (7.5%); all other provinces were below 2.6%.

Water supply systems also have to meet people's needs when they are away from home. Canadians enjoy leisure time as Table 1.3 illustrates. Some 551 000 households have vacation homes while 2.6 million have overnight camping equipment.

1.3 Municipal Public Water Supply Systems

In 1963 it was estimated that groundwater supplied 9.7% of the water used in municipal water systems across Canada, which at that time were estimated to serve a total of 14.9 million people. Some 324 or 36.7% of the 883 municipal systems obtained some or all of their water from wells[7]. A more recent

Table 1.1
Urban and Rural Population by Province and Territory in 1986

	1986 Population				% Change, 1981 to 1986		
Province/Territory	Urban	Rural	Total	Rural as % of Total	Urban	Rural	Total
Newfoundland	334 732	233 617	568 349	41.1	0.6	-0.5	0.1
Prince Edward Island	48 289	78 357	126 646	61.9	8.5	0.5	3.4
Nova Scotia	471 127	402 049	873 176	46.0	0.9	5.6	3.0
New Brunswick	350 303	359 139	709 442	50.6	-0.8	4.6	1.9
Quebec	5 088 995	1 443 466	6 532 461	22.1	1.9	-0.1	1.5
Ontario	7 469 420	1 632 274	9 101 694	17.9	6.0	3.4	5.5
Manitoba	766 851	296 165	1 063 016	27.9	5.0	0.2	3.6
Saskatchewan	620 198	389 415	1 009 613	38.6	10.1	-3.9	4.3
Alberta	1 877 758	488 067	2 365 825	20.6	8.7	-4.3	5.7
British Columbia	2 285 004	598 363	2 883 367	20.8	6.8	-1.1	5.1
Yukon	15 199	8 305	23 504	35.3	2.6	-0.4	1.5
Northwest Territories	24 209	28 029	52 238	53.7	10.1	18.0	14.2
Canada	19 352 085	5 957 246	25 309 331	23.5	5.0	0.8	4.0

Note: Urban area defined by Statistics Canada as having a population concentration of 1000 or more and a population density of 400 or more per square kilometre. Rural area refers to all territory lying outside "urban areas".

Source: Statistics Canada: Special Request by DGB Enviroconsultants

Table 1.2
Rural Farm Households and Populations by Province and Territory in 1986

Province/Territory	Number of Rural Farm Households	Population of Average Rural Farm Household	Total Population in Rural Farm Households	Rural Farm Population as a % of Total Population
Newfoundland	400	4.2	1 685	0.3
Prince Edward Island	2 640	3.9	10 275	8.1
Nova Scotia	3 865	3.7	14 175	1.6
New Brunswick	3 185	3.8	12 110	1.7
Quebec	36 420	3.9	143 380	2.2
Ontario	65 220	3.6	232 790	2.6
Manitoba	23 020	3.7	84 690	8.0
Saskatchewan	46 730	3.5	161 495	16.0
Alberta	49 830	3.6	178 115	7.5
British Columbia	15 330	3.4	51 775	1.8
Yukon	-	-	-	-
Northwest Territories	-	-	-	-
Canada	246 640	3.6	890 490	3.5

Note: - = nil
Source: 7

review of groundwater utilization, conducted in 1981, estimated that municipal and rural users accounted for half of all the groundwater used in Canada[6]. Some 2.2 million people supplied by municipal systems and 4.0 million people in rural areas, or 26% of the total population, were estimated to depend on groundwater for their domestic requirements. These estimates are summarized by province and territory in Table 1.4.

Comprehensive records on drinking water sources of rural residents do not exist since rural systems have been built by individuals for their own purposes. The estimates in Table 1.4 were derived from: a) Total population figures provided by census data, b) Population served by municipal distribution networks provided by MUNDAT, Environment Canada's national inventory of municipal waterworks and wastewater systems, c) Rural population deduced as the difference between the total population and those served by municipal distribution networks, d) Groundwater users in the municipal distribution networks estimated on the basis of MUNDAT data concerning water sources for each system, e) Groundwater users estimated to account for 90% of the rural population in most provinces or territories, and different percentages in the few others.

The 1984 data from MUNDAT in Table 1.5 indicated approximately 2.8 million or 13% of all Canadians living in municipalities relied on groundwater as their total or partial source of water supply and approximately 39% or 1078 of 2735 municipalities on distribution networks across Canada used groundwater for some or all of their supply (The numbers of the population relying on groundwater differs by about 0.57 million between Tables 1.4 and 1.5. It should not be inferred that the number of people reliant on groundwater in municipalities increased from 2.2 million in 1981 to 2.8 million in 1984. Although some of the difference in the higher estimate in Table 1.5 can be attributed to more recent data, the main reason is due to the processing of the data. In Table 1.5 the population relying on groundwater was derived from summing the served populations of municipalities totally or partially relying on groundwater. The population relying on groundwater in Table 1.4 is lower because population figures were prorated to the percentage of the total water flow obtained from groundwater sources).

Of the 1078 municipalities relying on groundwater, about 68% rely on it as their only source. In terms of water flow, about 76% of water obtained for these municipalities is from groundwater. Table 1.5 provides a breakdown of these water systems by provinces and territories based on statistics available from MUNDAT.

MUNDAT provides municipal data on water supply and wastewater systems collected by provincial/territorial governments which is then given to the Environmental Protection Program Directorate of Environment Canada on an ongoing basis. Data for various parameters such as source of supply, served populations, and water treatment are provided by municipalities. Provincial, territorial, and national tabulations have been compiled based on this data. The 1975 and 1981 data have been published, and current data is available upon request. Although MUNDAT provides the only available ongoing source in presenting an overview of municipal water systems across Canada, the data input relies on reported values. Consequently the figures shown on Table 1.5 should not be considered accurate or complete.

Table 1.3
Vacation Homes and Camping Equipment by Province in May 1987

Province	Total Households × 1000	Population of Average Household	Households with Vacation Homes × 1000	Households with Overnight Camping Equipment × 1000
Newfoundland	168	3.42	14	40
Prince Edward Island	43	2.92	--	8
Nova Scotia	313	2.82	21	76
New Brunswick	246	2.87	18	62
Quebec	2 530	2.68	174	529
Ontario	3 451	2.70	214	833
Manitoba	405	2.61	28	123
Saskatchewan	378	2.69	19	130
Alberta	872	2.69	34	360
British Columbia	1 149	2.52	27	418
Canada	9 556	2.69	551	2 579

-- = amount too small to express

Notes: 1. Overnight camping equipment includes tents, tent trailers, travel trailers and truck campers but excludes mobile homes.
2. Estimates made on basis of sample surveys.
3. Figures may not add to totals shown due to rounding.

Source: 8-Tables 1.1, 7.4 and 7.6.

1.4 Water Supply for Permanent Residents in Rural Areas

The definition of a rural user according to the NHRI report[6] is someone who is not served by a municipal distribution network. In 1981 there were about 4.9 million people who were classified as rural users, with about 82% using groundwater as their source of water supply (Table 1.4). Considering that there are about 1 million people living on farms (Table 1.2) the other 3 million must be either living in small communities or in isolated areas. People living in such small communities rely either on a communal distribution network or on an individual private system for their water supply. People in isolated areas have to rely on their own private system.

The farm population has to rely on private systems in most cases. Response from a 1965 questionnaire in Ontario revealed that the majority of farmers surveyed used drilled and dug wells as their source of supply for household use and livestock use. Other sources included bored wells, cisterns, ponds, and public utilities (Table 1.6). The non-domestic water needs of the farms can be supplied from lower quality sources than the water for human consumption.

An extensive review[11] of farm water use in Ontario has shown that:

"Water for farm homes and barns comes mostly from drilled wells. Dug wells are second in importance, occurring only about one half that of drilled wells. Cisterns are a water source around the central and southern townships of the Niagara peninsula. Bored wells, dugout ponds, springs and lakes are only a minor source, depending on the locality. Water for livestock is mostly relied on from drilled wells. Dugout ponds, springs and lakes are used more for livestock than for the farm home".

Provincial agriculture departments in Saskatchewan, Manitoba and Alberta have set up special programs to provide technical and financial assistance for water supplies for farms. The federal government has been a major participant in these programs through the Prairie Farm Rehabilitation Administration (PRFA), which was created in 1935 and is now part of Agriculture Canada. Further information on PFRA is provided in Annex 5. Particular programs of these agencies which relate to shallow wells and precipitation catchments are discussed in the following sections. Drinking water, which is the focus of this study, forms a very small part of the total water requirements of most farms[1].

Restaurants and gas station employees and patrons as well as employees of small industries located along many of Canada's highways and secondary roads probably obtain most of their water supply from groundwater and would be as concerned as local residents about the quality of groundwater supplies.

1.5 Water Supply for Cottagers and Campers

In vacation periods, particularly in the summer, many Canadians go to campsites and cottages. If just half of the 551 000 cottages and 2 579 000 camping outfits summarized in Table 1.3 are in use on a peak summer weekend, for example,

Table 1.4
Summary of NHRI Estimate of Population Dependent on Groundwater in 1981

Data Identification	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yuk.	N.W.T.	Canada
Municipal Water Users (× 1000)													
Reliant on groundwater	16	33	34	135	412	904	47	205	112	296	14	0.2	2 209
Total	405	33	460	348	5 645	7 424	807	615	1 684	1 980	21	381	9 461
% groundwater users/total	4	100	7	39	7	12	6	33	7	15	65	1	11
Rural Water Users (× 1000)													
Reliant on groundwater	146	89	349	314	715	1 081	197	318	498	306	1	0.1	4 013
Total	162	89	387	348	793	1 201	219	353	553	765	1.9	8.1	4 882
% groundwater users/total	90	100	90	90	90	90	90	90	90	40	50	1	82
Municipal + Rural Users (× 1000)													
Reliant on groundwater	162	122	383	449	1 126	1 985	244	523	610	602	15	0.3	6 223
Total	567	122	847	696	6 438	8 625	1 026	968	2 237	2 745	23	46	24 343
% groundwater users/total	29	100	45	64	17	23	24	54	27	22	63	1	26

Notes: 1. Due to rounding, percentages may not correspond.
2. Officials have no updated values available.

Source: 6

there would be some 1.6 million households or 4.2 million people living throughout the countryside. The number of people who visit Canada's campgrounds and parks is also augmented by foreign visitors, mainly in the summer months. Water-quality concerns are particularly important from the perspective of the tourist industry.

1.6 Groundwater Contamination Studies

A recent review[12] of groundwater contamination listed 21 sources other than acid rain. Considerable research on groundwater contamination has been undertaken in recent years by provincial and federal authorities and other researchers. Environment Canada has recently examined the studies of 174 documented cases of groundwater contamination from coast to coast[13].

1.7 Acidic Deposition Studies

An extensive body of knowledge has been accumulated within the past decade on various impacts of acidic deposition on water resources under the Long Range Transport of Air Pollutants (LRTAP) program. Further information can be obtained from the LRTAP Coordination Office listed in Annex 4.

The federal government, in conjunction with other agencies, has been investigating the impacts of acid rain on forests at three specific locations:

a) Turkey Lakes, north of Sault Ste. Marie in the Algoma district of Ontario;

b) Lac La Flamme, north of Quebec City; and

c) Kejimkujik National Park in Nova Scotia.

Much of the forest-related research deals with interactions between precipitation and quality changes in surface and groundwaters and could be relevant to concerns about domestic groundwater quality changes.

Another source of relevant research and expertise is Atomic Energy of Canada Limited, which has carried out extensive investigations at two sites:

a) Chalk River, Ontario — more than 20 years of study of water quality of surface waters and interaction with groundwater; and

b) Pinawa, Manitoba — some 10 years of research related to the deep disposal in bedrock of high-level radioactive wastes.

Further examination of the potential risk posed by acid rain to public health through changes in groundwater quality will, in practical terms, require detailed monitoring of local aquifers selected on the basis of exposure to acid rain and geologic conditions.

Future studies aimed at investigating the impacts of acidic deposition on the quality of drinking water pumped from aquifers should take account of the extensive research completed in recent years concerning the sensitivity of terrestrial ecosystems to acidic deposition. Most of the prairie provinces, for example, are covered by soils which can effectively buffer and neutralize acidic precipitation so that aquifer water quality may be little affected.

Initial mapping of the sensitivity of Eastern Canada to acidic deposition was completed in 1983. Further research has been carried out since then in Ontario, Quebec and Nova Scotia. The first three-year research program for LRTAP in Western Canada (1982-85) has resulted in the production of compatible maps of soils and bedrock sensitivity to acidic deposition[14] which should facilitate the selection of any future areas for more applied research on drinking water quality related to LRTAP.

Table 1.5
Water Supply Systems - Extent of Services by Province and Territory

Data Identification	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yuk.	N.W.T.	Canada
Total pop. surveyed (× 1000)	497	58	546	410	6 367	8 195	839	611	1 898	2 307	22	44	21 793
No. of communities surveyed	322	23	111	88	1 490	447	281	140	417	147	8	50	3 524
No. (× 1000) and % of pop. served by municipal distribution networks	454 91%	44 77%	496 91%	365 89%	5 967 94%	8 143 99%	813 97%	611 100%	1 895 99.8%	2 303 99.8%	21 97%	38 81%	21 149 97%
No. of communities with a distribution network	229	6	83	64	1 024	422	199	140	387	140	6	35	2 735
No. (× 1000) and % of pop. served by water treatment	359 79%	21 47%	462 93%	266 73%	4 925 83%	6 913 85%	785 97%	599 98%	1 832 97%	1 848 80%	19 89%	38 100%	18 072 85%
No. (× 1000) and % of pop. on distribution networks reliant on groundwater as their supply source	12 2.6%	44 100%	63 13%	75 20%	493 8%	1 277 16%	55 7%	321 53%	167 9%	257 11%	19 89%	0.2 0.5%	2 783 13%
No. of communities relying totally or partially on groundwater sources (No. of wells)	35 (91)	5 (73)	23 (56)	46 (137)	316 (681)	204 (584)	81 (95)	115 (276)	200 (300)	44 (130)	6 (17)	3 --	1 078 (2 427)
% of communities relying totally on groundwater sources	63%	40%	61%	57%	48%	96%	64%	87%	70%	59%	100%	67%	68%
% of total water obtained from groundwater by communities who totally or partially rely on groundwater	80%	100%	58%	90%	82%	81%	49%	59%	80%	57%	99%	--	76%

Notes: 1. Based on information provided by municipalities and provinces, some of which may be incomplete.
2. The term "municipality" varies throughout the provinces and territories. For example, in Quebec, data were collected for communities which had populations as low as 20 people while, in British Columbia, data were usually collected for communities of 600 or more.
3. In some cases, it is possible some data are not being updated. For example, personal communications with municipal officials while working on the "Ground Water Use in Canada, 1981" project indicated discrepancies between MUNDAT and municipal data in the communities of Regina and Whitehorse. It is not known if similar discrepancies occur elsewhere.

Source: 1984 MUNDAT data provided by provincial/territorial governments and compiled in September, 1986 on MUNDAT system of Environmental Protection Program Directorate of Environment Canada. (data is being updated but is not yet available)

One researcher [12] has summarized the situation concerning groundwater contamination in Canada succinctly:

"Unconfined aquifers are particularly prone to contamination from a myriad of potential chemical sources such as septic systems, buried gasoline tanks, road salt, fertilizer, pesticides, chemical spills, landfills, and industrial lagoons. There are millions of wells in unconfined aquifers and millions of these point sources. Groundwater contamination generally takes years or decades to develop and is often not detected until it has spread considerably from the source.

"The number of groundwater users that will be exposed to groundwater contamination will gradually increase in the next few decades. Groundwater research in Canada is meagre in quantity and priorities do not bear much relation to the types of contamination problems that present evident risk to groundwater users or to surface water users where surface impacts are caused by contaminant transport through the groundwater zone."

1.8 Other Relevant Parameters

An important factor in determining areas where groundwater is vulnerable to acid rain is the geology. The Geological Survey of Canada and provincial agencies have mapped the geology of most of Canada at scales from 1:50 000 to 1:1 000 000. This information can provide an overview of whether an area is naturally acidic or alkaline, and thereby indicate the buffering capacity to acid rain.

At the provincial level more detailed geologic mapping has been compiled for many areas. For instance, Manitoba has categorized and mapped farm groundwater supply potential based on geological data. In Nova Scotia pH levels for surface water have been mapped at a scale of 1:2 000 000. The variations of pH levels correspond with changes in geology.

The distribution of population has been mapped by the National Atlas of Canada. This demographic distribution may suggest eliminating areas where sparse population occurs. However, conversely, sparsely populated areas may identify sites where the influence of man is minimal.

Table 1.6
Sources of Farm Water Supply for Household and Livestock Use in Ontario

Sources of Water	Household Use Number of Farms Reporting	Livestock Use Number of Farms Reporting
Drilled Well	13 418	13 808
Bored Well	1 028	947
Dug Well	11 807	9 202
Cistern	7 973	1 724
Sand Point	933	785
Stream, Lake or Stream-fed Pond	1 026	6 215
Dugout Pond	789	4 923
Public Utility	807	448
Other	683	1 694

Notes: 1. There were 30 262 (30.5%) respondents out of 99 000. Totals exceed 30 262 due to multiple use in each category.
2. 19 688 out of 28 529 (69.0%) respondents said the same source was used for both household and livestock use.

Source: 10

Seasonal distribution and quantities of precipitation are available from the Atmospheric Environment Service (Environment Canada) and have been mapped by the National Atlas of Canada.

1.9 Groundwater Expertise

Environment and health departments of the provincial and federal governments are aware of the extensive research on groundwater contamination, much of which would be relevant to any planned future research which relates drinking water quality from well sources with acidic precipitation.

There is also a small but very important community of groundwater specialists in Canada whose interest and expertise should be incorporated in any subsequent investigations on this topic. These individuals work in the public and private sectors across Canada and frequently deal with one another on an informal basis. There are three professional associations which could be used to access and involve these specialists.

a) The Canadian National Chapter of the International Association of Hydrogeologists (IAH/CNC) was formed in 1972 and has about 240 members, mostly scientists, consultants and researchers. They receive a bi-monthly newsletter plus proceedings from international symposia held in Canada and elsewhere organized or sponsored by IAH. The Canadian National Chapter of IAH has held three national conferences (Edmonton in 1980, Winnipeg in 1982, and Saskatoon in 1986) and two international conferences (Montreal in 1984, and Halifax in 1988).

b) The Canadian Water Well Association (CWWA) has about 350 members, including some of the estimated 1200 well drillers in Canada. CWWA is basically the aggregation of regional water well associations which exist in most provinces. CWWA communicates with its members through its newsletter in the quarterly publication "Canadian Water Well". In 1986 CWWA held its annual meeting in Saskatoon jointly with the Canadian Chapter of IAH.

c) The National Water Well Association (NWWA) based in Dublin, Ohio, has some 14 000 members and is a very strong body with five operating divisions, including about 3000 water well contractors. There are 185 Canadian members of the technical division known as the Association of Ground Water Scientists and Engineers. The Association has prepared a foreign market report on available information about water wells in Canada which is sold to those such as equipment suppliers who seek an assessment of the extent of groundwater use in Canada.[15,16] A more extensive analysis of the U.S. market estimated that 810 000 water wells were drilled there in 1985, including 489 000 for private households[17].

Considerably more research on groundwater quality protection has been undertaken in other countries, primarily because they are more dependent than Canada on aquifers for their drinking water. The Office of Groundwater Protection, which, within the U.S. Environmental Protection Agency was established in 1984, may be able to provide information on U.S. experience. Careful review of experience in the U.S.A. and elsewhere, particularly Europe, would be appropriate in the context of devising suitable Canadian strategies and programs for the evaluation and protection of groundwater quality.

2. Shallow Well Drinking Water Supplies

2.1 General

Groundwater has not been the dominant source of drinking water in Canada because most urban settlements were located near rivers or lakes which provided abundant supplies of fresh water and few urban centres have easy access to aquifers which could supply potable water as cheaply. Furthermore, knowledge about groundwater has been developing slowly and is still incomplete in many areas and even hydrogeologists admit that they are just beginning to understand its complexities[1]. There are only about 250 hydrogeologists in Canada today[2] and hydrogeology and/or groundwater hydrology is taught at 10 Canadian universities. The largest program is at the University of Waterloo in Ontario, which has produced 140 graduates since its inception in 1971. Only a few individuals and groups are knowledgeable about both hydrogeology and the health implications of the quality of drinking water.

The federal government, through the Geological Survey of Canada, was active in groundwater inventory work until about 1959, and provincial agencies have been systematically compiling well inventory data for most of the past thirty years. Beginning with Ontario in 1946, each province has developed its own system for acquiring and maintaining groundwater data. No provincial authority has been able to document all use of its groundwater sources since hand-dug shallow wells and springs are seldom reported. In the early 1970s the federal government tried to assist in standardizing a data system covering groundwater use and quality. This computerized system was known as GOWN (Groundwater Observation Well Network). Although the federal government spent significant time and funds on the GOWN database, the system was abandoned because of practical problems including high costs and incompatible systems[3].

Groundwater exists beneath the land surface throughout Canada. In the populated southern part of the country, except in mountainous areas, the water table generally lies within 20 metres of the surface and is rarely deeper than 30 metres. Aquifers are permeable geologic formations which can sustain water yield at rates that are useful to people. The location and extent of large regional aquifers in southern Canada are reasonably well documented. But there are many thousands of small aquifers in sand and gravel deposits, each capable of supplying water at tens or hundreds of litres per minute. These smaller aquifers are so numerous that their location and size generally do not appear on maps of geologic deposits or groundwater resources[4].

Shallow wells, the primary focus of this study, exist in all parts of Canada. (Shallow wells have been defined for this study as wells less than 15 metres deep.) Identifying and categorizing all shallow wells would only be possible through an expensive and time-consuming survey. Only very limited information is available in provincial archives, well drillers' records, and other sources. Nevertheless the information at hand is considered sufficiently representative to characterize the nature and extent of groundwater use for drinking water at the provincial/territorial level across Canada. The approach taken in this report is to present informed estimates of shallow groundwater use based upon a review of the present state of information concerning wells and groundwater use in all the provinces and territories. The data obtained from each region has been tabulated and is summarized in this section. A national overview is presented followed by provincial and territorial overviews.

2.2 National Overview

2.2.1 Water Well Data

Table 2.1 summarizes information provided by provincial and territorial agencies on water well records. The reliability of the data presented in this Table must be qualified as being reasonable representations but certainly does not account for all wells in current use. Eight of the provincial data banks of well records are computerized. The Prince Edward Island, Saskatchewan, Alberta and Ontario systems are apparently able to search the existing records and sort water wells by depth and by location. Drillers in British Columbia, the Yukon and Northwest Territories are not required to file water well records. In six provinces and two territories, records do not have to be filed for wells dug by contractors. Records are not required to be submitted for wells dug by individuals in any province except British Columbia where only contractors are allowed to dig wells. None of the provinces or territories require water

quality analyses as part of the well records. There are about 1 million records of water wells available in all of the files across Canada. It is estimated that the number of recorded drilled wells is over 800 000, and dug wells over 200 000. As it is often not necessary for individuals or contractors to file reports of dug wells, the 200 000 estimate is probably very low.

The existing water well records cover far more than just the wells used to supply drinking water to people. These records include test wells, recharge wells and observation wells in addition to production wells. In Alberta the majority of records added to the data file recently are structure test borehole electric logs (E-logs) and not drillers' records. Furthermore many of the water wells are used for livestock, industry, irrigation or other non-potable purposes. Finally many of the water wells included in the records have long since been abandoned.

2.2.2 Groundwater Users of Wells Shallower than 15 Metres

Officials in most of the provinces and territories have provided updated estimates on the numbers of municipal and rural groundwater users. In addition, some information was obtained on the number of wells shallower than 15 metres and the population served by them. However, estimates of groundwater use by temporary residents could not be provided because only fragmented data were available.

This subsection is divided into three parts: municipal public water supply systems, rural water supply for permanent residents and water supplies for cottagers and campers.

2.2.2.1 Municipal Public Water Supply Systems

Approximately 14.3% or 3.4 million Canadians in the eight provinces and two territories, as reported in Table 2.2, rely on groundwater from municipal water supply systems. Extrapolating suggests that 3.62 million Canadians rely on groundwater from municipal public supply systems. Of the municipal population relying on groundwater, those relying on wells shallower than 15 metres could only be estimated for Saskatchewan (22.5%) and British Columbia (26.5%). In Manitoba, where a distinction is made between confined and unconfined aquifers, less than 10% of the municipal population obtain potable water from unconfined aquifers. Extrapolation suggests about 450 000 Canadians relying on groundwater from municipal public water supply systems obtain their supply from wells shallower than 15 metres. For municipalities in seven provinces and one territory which rely on groundwater from municipal water supply systems, it is estimated 724 or 25.8% of their wells are shallower than 15 metres.

2.2.2.2 Rural Water Supply for Permanent Residents

Approximately 3.15 million Canadians in eight provinces and two territories rely on individual groundwater supply systems (Table 2.3). Extrapolating suggests that about 3.33 million Canadians rely on groundwater from private individual systems. Furthermore, for six provinces and one territory where a breakdown into shallow and deep wells is possible, approximately 28%, or 0.88 million people out the of 3.15 million, relied on individual wells shallower than 15 metres. This suggests that nationally about 1.55 million rural users on private individual systems rely on groundwater from wells shallower than 15 metres. Six provinces and one territory have provided estimates which indicate that about 1.08 million wells are used by 3.15 million rural residents. This estimate is partially derived from pro-rating the number of wells based on population as opposed to documented use. Extrapolation suggests that, nationally, there could be about 1.88 million wells in rural areas used by 3.33 million Canadians on individual systems. Estimates provided by six provinces and one territory further indicate that about 34% of the 1.08 million reported individual wells used were shallower than 15 metres. Extrapolation suggests that, nationally, there could be about 640 000 wells shallower than 15 metres used for domestic purposes by the 1.55 million rural residents on individual systems.

2.2.2.3 Water Supplies For Cottagers and Campers

Estimates of water use for cottagers and campers in Canada are not possible since hardly any data exist (as shown in Table 2.4). Most vacation sites are near water bodies. However, some of these surface waters are not potable and groundwater is used for drinking purposes. Communal systems may also be important for a portion of these seasonal residents, many of whom are located in summer villages including organized campsites.

In Nova Scotia, 55 000 seasonal residents on communal systems rely on groundwater. Officials in Ontario estimate between 30 000 and 50 000 wells are used to supply individual water systems for seasonal residences in the province. For Nova Scotia, British Columbia and Manitoba, most individual water systems are supplied by surface sources.

2.2.3 Location of Aquifers and Areas of Shallow Well Use

To present the available groundwater information graphically presents major challenges. Ideally maps could be prepared, perhaps using overlays, to provide all relevant groundwater data at the same scale. One author[5] has suggested that a set of five maps would be appropriate for hydrogeological mapping, covering: Bedrock Hydrogeology, Quaternary Hydrogeology, Groundwater Regime, Groundwater Resources, and Hydrochemistry of Main Aquifers. He also notes that very little regional hydrogeological mapping and groundwater resources evaluation has been done to date in Canada.

Table 2.1
Basic Estimated Data on Water Wells by Province and Territory

Data Identification	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yuk.	N.W.T.
Well Records												
Year of earliest record	1950	1970	1940	1973	1954	1946	1900?	1900	1900	1961	--	--
Year when routine recording of all new wells began	1983	1970	1965	1973	1967	1946	1963	1959	1970	1961	--	--
Compulsory for drillers to submit well logs?	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N
Water quality analysis required with well logs?	N	N	N	N	N	N	N	N	N	N	N	N
Well logs filed for wells dug by contractors?	N	Y	Y	N	N	Y	N	N	N	Y	N	N
Well logs filed for wells dug by individuals?	N	N	N	N	N	N	N	N	(b)	Y	N	N
Number of new well logs recorded for 1987	na	na	na	na	na	15 911	na	1 603	na	na	na	na
Total number of well logs on file in December, 1987 (× 1000)	7	11	50	20	100	320	50	111[a]	300	60	--	--
Computerized data system?	Y	Y	N	Y	Y	Y	Y	Y	Y	N	N	N
Estimated total number of drilled wells (× 1000)	8	35	80	80	na	275	na	60[c]	245	na	na	na
Estimated number of wells drilled in 1987	na	na	na	na	na	16 000	na	979[c]	na	na	na	na
Estimated total number of dug wells (× 1000)	60	0.5	50	20	na	29	1	25[d]	56	na	na	na
Estimated number of wells dug in 1987	na	na	na	na	na	na	na	624[d]	na	na	na	na
Well Drillers												
Registration compulsory?	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N
Experience or other qualifications required?	Y	N	Y	Y	N	Y	N	N	Y	N	N	N
Formal training required?	N	N	N	N	N	N	N	N	Y	N	N	N
No. of drilling companies active in 1987	6	7	90	40	194	250	46	86	229	na	4	na
No. of drill rigs active in 1987	8	11	100	na	400	na	73	143	na	na	7	na

Notes: (a) Only water wells (i.e.no test wells)
(b) Only licensed drillers can construct wells
(c) >15 metres deep
(d) <15 metres deep
Y = Yes, N = No, na = not available.

Sources: Water Resources Division, Newfoundland Department of Environment; Water Resources Section, Prince Edward Island Department of Community and Cultural Affairs; Water Resources Planning, Nova Scotia Department of the Environment; Water Resources Planning Branch, New Brunswick Department of Municipal Affairs and Environment; Direction générale des ressources hydriques, Ministère de l'Environnement (Québec); Water Resources Branch, Ontario Ministry of the Environment; Water Resources Branch, Manitoba Department of Natural Resources; Resources Management, Saskatchewan Water Corporation; Alberta Water and Wastewater Facilities Survey, 1985: Pollution Control Division, Alberta Environment, 1986; Water Management Branch, British Columbia Ministry of Environment; Municipal Engineering, Yukon Department of Community and Transportation Services; Water Resources Division, Indian and Northern Affairs Canada.

Table 2.2
Estimated Municipal Systems and Groundwater Use by Province and Territory, 1987

Data Identification	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yuk.	N.W.T.
Total number of systems	--	9	50	--	1 075	471	197[f]	556	655	504[d]	19	40
Total population served (× 1000)	--	35	500	--	6 351	7 600	831	701	2 006	2 566	24	46
Number of systems with distribution networks	--	9	50	--	925	534	197[f]	509	412	504	8	12
Population served by systems with distribution networks (× 1000)	--	35	500	--	na	7 500	831	695	2 000*	2 566	21	na
Number of systems using only groundwater	--	9	17	--	413	250	58	364	362	215	5	1
Population served by systems using only groundwater (× 1000)	--	35	33	--	1 200	1 300	71	172	130	161	3	0.2
Number of systems using groundwater and surface water	--	0	1(4)[a]	--	63	6	0	25	60*	27	2	0
Population served by systems using groundwater and surface water (× 1000)	--	0	16.5	--	na	100	0	210	180*	112	19	0
Estimated population served by groundwater share in systems using two sources (× 1000)	--	0	8	--	na	20	0	50	144**	28	15	0
Estimated total population served by groundwater (× 1000)	--	35	41	--	1 263[e]	1 320	71	222	274	189	18	0.2
Estimated total population served by groundwater from wells shallower than 15 metres (× 1000)	--	0	few	--	na	na	6.7[b]	50	na	50	na	na
Estimated number of wells in communal system:												
a) Shallower than 15 metres	--	0	8	--	na	50	15[b]	486	62	101	3	na
b) 15 metres or deeper	--	41	60	--	na	550	80[c]	793	238	311	8	na

Notes: (a) Including springs
(b) Unconfined aquifer
(c) Confined aquifer
(d) Ministry of Health is sampling an additional 500 waterwork systems; data will be available over the next few years
(e) Includes 63 000 people who also use surface water
(f) 1986 MUNDAT data
na = not available.
These systems serve permanent residences including farms and house trailers and exclude temporary residences such as vacation homes and campgrounds.

* Author's estimate based on previous values.
** Author's estimate based on 1986 MUNDAT data (Table 1.5 gives 80%).

Sources: Water Resources Section, Prince Edward Island Department of Community and Cultural Affairs; Water Resources Planning, Nova Scotia Department of the Environment; Direction générale des ressources hydriques, Ministère de l'Environnement (Québec); Water Resources Branch, Ontario Ministry of the Environment; Water Resources Branch, Manitoba Department of Natural Resources; Resources Management, Saskatchewan Water Corporation; Alberta Water and Wastewater Facilities Survey, 1985; Pollution Control Division, Alberta Environment, 1986; Water Management Branch, British Columbia Ministry of Environment; Municipal Engineering, Yukon Department of Community and Transportation Services; Indian & Northern Affairs Canada, Water Resources Division.

Table 2.3
Estimated Individual Systems for Permanent Residences by Province and Territory, 1987

Data Identification	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yuk.	N.W.T.
Total population in 1986 (× 1000)*	568	127	873	709	6 532	9 102	1 063	1 010	2 366	2 883	24	52
Population served by municipal water systems (× 1000)**	--	35	500	--	6 351	7 600	831	701	2 006	2 566	23	46
Population served by individual water systems (× 1000)	--	93	387	--	338	1 500	246	310	360	340	4	6"**"
Estimated Population Served by Individual Water systems According to Principal Water Source:												
Rivers and lakes (× 1000)	--	0	6	--	na	na	20	na	na	20	0.4	na
Rainwater catchments including dugouts (× 1000)	--	0	1	--	na	na	4	na	na	20	na	na
Groundwater (× 1000)	--	93	380	--	325	1 300	212	230	"315"[(c)]	295	2.7	0.5"**"
Groundwater from wells shallower than 15 m (× 1000)	--	10-20	145	--	na	520	22	90	90	na	na	na
Water by truck (× 1000)	--	0	0	--	na	na	10	na	na	5	6[(d)]	na
Other sources (× 1000)	--	0	0	--	na	300	0	na	na	0	na	na
Estimated Number of Water Wells: (× 1000)												
a) Shallower than 15 metres	--	5	80	--	na	200	8[(a)]	19	55	na	0.3	na
b) 15 metres or deeper	--	30	50	--	na	300	79[(b)]	41	214	na	0.45	na

Notes: (a) Unconfined aquifers
(b) Confined aquifers
(c) Include some users of rainwater catchments
(d) Trucked from B.C.
"#" = same ratio as previous report used, "**" = difference, na = not available, -- = reply not received.
These systems serve permanent residences including farms and house trailers and exclude temporary residences such as vacation homes and campgrounds.

Sources: Water Resources Section, Prince Edward Island Department of Community and Cultural Affairs; Water Resources Planning, Nova Scotia Department of the Environment; Direction générale des ressources hydriques, Ministère de l'Environnement (Québec); Water Resources Branch, Ontario Ministry of the Environment; Water Resources Branch, Manitoba Department of Natural Resources; Resources Management, Saskatchewan Water Corporation; Alberta Water and Wastewater Facilities Survey, 1985: Pollution Control Division, Alberta Environment, 1986; Water Management Branch, British Columbia Ministry of Environment; Municipal Engineering, Yukon Department of Community and Transportation Services.

* Statistics Canada
** Municipal (see Table 2.2)

Table 2.4
Estimated Water Supplies for Temporary Residences by Province and Territory, 1987

Data Identification	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yuk.	N.W.T.
Temporary Residences												
Number of household vacation homes (× 1000)	--	na	20	--	na	200	28	na	na	20.4	1.5	na
Number of households with overnight camping equipment (× 1000)	--	na	73	--	(f)	na	107	na	na	na	na	na
Communal Water Systems												
Number of communal systems	--	na	na	--	925	na	5	300[d]	na	1 000[d]	na	na
Estimated population served by groundwater (× 1000)	--	na	55	--	na	na	4.1	na	na	na	na	na
Estimated number of wells (× 1000)												
a) Shallower than 15 metres	--	na	na	--	na	na	0[b]	120	na	na	na	na
b) 15 metres or deeper	--	na	50	--	na	na	5[c]	180[d]	na	na	na	na
Estimated Number of Individual Water Systems Supplied from (× 1000):												
Rivers and lakes	--	0	15[e]	--	na	na	10.5	na	na	18	na	na
Rainwater catchments	--	0	1	--	na	na	0	na	na	1	na	na
Water wells												
a) Shallower than 15 metres	--	na	3	--	na	30-50	1[b]	na	na	1	na	na
b) 15 metres or deeper	--	na	2	--	na	na	8	na	na	0.4	0.1	na
Carried from elsewhere	--	0	(a)	--	na	na	7	na	na	na	na	na
Other systems	--	na	na	--	na	na	0	na	na	na	na	na

Notes: (a) Included within "Supplied from rivers and lakes"
(b) Unconfined aquifers
(c) Confined aquifers
(d) These systems would serve permanent and temporary homes and includes parks
(e) Not used for drinking water
(f) 906 campgrounds and 75,577 campsites in 1983
na = not available, -- = reply not received.

Sources: Water Resources Section, Prince Edward Island Department of Community and Cultural Affairs; Water Resources Planning, Nova Scotia Department of the Environment; Direction générale des ressources hydriques, Ministère de l'Environnement (Québec); Water Resources Branch, Ontario Ministry of the Environment; Water Resources Branch, Manitoba Department of Natural Resources; Resources Management, Saskatchewan Water Corporation; Alberta Water and Wastewater Facilities Survey, 1985: Pollution Control Division, Alberta Environment, 1986; Water Management Branch, British Columbia Ministry of Environment; Municipal Engineering, Yukon Department of Community and Transportation Services.

In this study the approach taken is to show the location of aquifers and identify these areas where there is reported to be substantial reliance on shallow wells on a series of six regional maps (Annex 6). These are the same base maps used in the NHRI report on groundwater use[6]. (Manitoba data is divided between confined and unconfined aquifers). The basic aquifer identification shown on these regional maps comes from reports prepared by consultants for the National Research Council covering the Prairie Provinces[7], the Atlantic and Maritime Provinces[8] and Ontario[9]. For Quebec, British Columbia and the Northwest Territories, the basic information comes from surficial and bedrock geological maps in Canada's hydrological atlas which was published in 1978[10].

2.2.4 Discussion

The data presented in Tables 2.1 through 2.4 provide an overview of the situation in Canada. Highlights from these tables indicate that there are about 1 million wells used for various purposes documented in data files throughout Canada. Extrapolations based on incomplete provincial and territorial estimates of groundwater use, indicate there are probably in the order of 1.88 million wells used for domestic purposes across Canada of which 0.64 million are shallower than 15 metres and are used by about 1.55 million Canadians to obtain their domestic supply of groundwater.

The main reason why more significant data are not available is because the objectives of the provincial data systems were not originally focussed on analyzing the quantitative and qualitative aspects of groundwater on a national basis. An extract from typical provincial legislation, the Saskatchewan Ground Water Conservation Act of 1978, reads as follows: "The purposes of this Act are: (a) to obtain logs of wells drilled and information on formations and materials encountered during drilling operations in order to assist in ground water and geological studies; and (b) to provide for the conservation, development and utilization of ground water resources and to prevent pollution and contamination of ground water." Water well records have been used primarily to provide information to those seeking to use groundwater and to provincial authorities concerned with controlling water use and protecting water resources. The data acquisition and management systems were not designed for the type of analysis attempted in the present study.

2.3 Provincial/Territorial Overview

This subsection focuses on identifying the types and sources of information available in each province and territory. Well recording formats are found in Annex 2, while well retrieval formats are found in Annex 3. The sequence used to report and analyze the data is the same as that used in publications available from Statistics Canada which provided data on Population Distribution, Rural/Urban Partitioning, and Rural Farm/Non-Farm Partitioning.

2.3.1 Newfoundland

The Atlantic Development Board was a federal agency formed to foster development by providing infrastructure in the Atlantic region. A comprehensive review of water resources in the four Atlantic provinces prepared for the Board utilized the services of four groups of consultants over a two-year period, resulting in a set of reports totalling 46 volumes[11].

A 1968 consultant's report on Newfoundland estimated that the majority of smaller communities were dependent on groundwater. Information on wells was reported to be scarce and of poor quality in the absence of legislation on well-drilling record-keeping. The report noted that most of the island is covered by superficial materials in which shallow wells can be dug to provide an adequate water supply for individual water systems although wells may dry up during the summer[12]. In 1987, it was estimated that there were 8000 drilled wells and 60 000 dug wells. (Table 2.1)

Hydrogeological studies covering seven areas of the province completed for the Groundwater Branch of the Water Resources Division of the Department of Environment between 1979 and 1985, are listed in Table 2.5. They exclude the south coast and the interior where access is very difficult and the population limited. Each report was based on a review of all available information but did not involve field studies. Reconnaissance maps covering bedrock and surficial geology were prepared. However, the absence of data on the many dug wells in their studies complicated the groundwater analysis for the shallow aquifers.

Table 2.5
Hydrogeology Reports of Areas in Newfoundland

Report No.	Area	Consultant	Report Date
2-1	The Great Northern Peninsula	Nolan, White & Associates Ltd.	1979
2-2	Notre Dame Bay	Hydrology Consultants Limited	1980
2-3	Bonavista Bay	Nolan, Davis & Associates Ltd.	1981
2-4	Trinity Bay	Nolan, Davis & Associates Ltd.	1982
2-5	Humber Valley	Golder Associates	1983
2-6	Avon Peninsula	Fracflow Consultants Inc.	1984
2-7	Burin Peninsula	Golder Associates	1985

The Well Drilling Act of 1981 and 1982 Well Drilling Regulations, both promulgated in 1983, require the licensing of well drillers and the submission of a water well record to the Department of Environment for every well drilled[13,14]. The Department had been collecting and compiling records of water wells drilled since 1950, relying on the goodwill of drillers and consultants to provide records prior to 1983. Records of a total of some 5000 wells drilled between 1950 and 1983 have been summarized by electoral district and published in a two-volume document of the Department of Environment [15]. The one-line

summary published for each well provides basic information including the owner, location, depth, static water level, casing data, and yield when available. This publication is the last for information on wells drilled prior to the Well Drilling Act. The Department also maintains detailed information required from drillers in hard copy form in an open file which is available for review. In 1986 a computer system to store water well records was established. Officials estimate about 7000 well logs are now on file (Table 2.1).

The NHRI report (Table 1.4) indicated that, in 1981, over 16 000 people served by municipal systems relied on groundwater as did over 146 000 rural residents. Provincial officials are not able to estimate the number of people using municipal systems and private systems dependent on shallow wells.

2.3.2 Prince Edward Island

No province is more dependent on groundwater than Prince Edward Island, since virtually all of the water used in the province comes from wells.

The comprehensive review of the publications prepared for the Atlantic Development Board (see section 2.3.1), provided a detailed evaluation of Prince Edward Island. In the summary report, the following statement is made: "In Prince Edward Island, bedrock aquifers almost anywhere can be expected to yield good quantities of water. Groundwater in the overburden deposits has remained virtually undeveloped because of the excellent source available in the bedrock. Generally, overburden deposits on the island will not be as good a source as the bedrock"[11]. The reports reviewed both the geology and hydrogeology of some 76 well records ranging in depth from 3 to 207 m; only six were shallower than 15 m[16].

Water quality in the period 1961–1973 had been assessed by Environment Canada, using NAQUADAT, which included 32 groundwater sites around the province. Most of Prince Edward Island waters were noted to be suitable for domestic consumption, but some would require at least minimal treatment. Of 18 parameters assessed, there was concern for the heavy metals (Pb especially), ammonia, and, to a lesser degree, turbidity, colour, and hardness[17].

Under the Well Drillers Act of 1974 and associated regulations, a permit is required to dig or bore a well, and every person, firm or corporation working as a well digger or a well driller requires a license[18]. A well record must be provided to the Department of Community and Cultural Affairs. They have been collecting drillers' logs since 1970 and now have a computerized data base covering some 11 000 wells. Up to 1000 new wells are drilled annually and these average 30 m. The total number of wells in Prince Edward Island, however, is very much larger than that recorded in the data base. It is likely that some 20 000 to 30 000 older wells have not been recorded. Dug wells are not common in Prince Edward Island and hardly any are believed to have been constructed in recent years. However, small-diameter hand drilled wells are common, particularly in Prince County, and these wells would normally be limited to 10 m.

Nine communities have piped water supplies and all use groundwater from wells ranging in depth from 21 m to 183 m (Table 2.2). There is little concern about the impact of acid rain on groundwater in the province. Carbonates in the overburden neutralize any acidity so that the pH level in most wells is above 7.0.

In 1986 some 35 000 people served by municipal systems relied on groundwater as did some 93 000 rural residents (Tables 2.2 and 2.3). Provincial officials familiar with the water supply situation and groundwater use estimate that, in 1987, none of the municipal systems relied on shallow wells but that some 10 000 to 20 000 rural residents relied on water from private shallow wells.

2.3.3 Nova Scotia

The comprehensive review of the publications prepared for the Atlantic Development Board (see Section 2.3.1), provided a detailed evaluation of Nova Scotia. In the summary report on Nova Scotia, the following statement is made: "In Nova Scotia, bedrock and overburden aquifers in certain locations can be expected to yield large quantities of groundwater. Groundwater resources of both the bedrock and overburden materials are considerably poorer in Nova Scotia than they are in New Brunswick"[11].

The detailed reports for each region of the province include summaries of more than 300 bedrock wells, of which approximately 10% are less than 15 m in depth. More than 100 wells in overburden are also summarized, of which about one third are less than 15 m in depth. The report includes a map locating the larger aquifers in overburden deposits which should help to define areas where shallow wells can be expected[16]. Dry wells are usually low water-yielding because of the till overburden. It was also noted that groundwater was of local origin and that, because of the overburden, pollution readily interacted with the water table[19]. Because of naturally occuring arsenic(As) contamination of water wells in Nova Scotia, the Nova Scotia Department of Health published a map indicating areas exceeding acceptable limits[20].

The protection and management of groundwater resources are the responsibility of the Department of the Environment. The Well Drilling Act of 1967 (slightly revised in 1986) requires well drillers to be licensed. Reports on each well drilled are to be submitted to the Department[21,22]. Approximately 50 000 well records have accumulated in provincial files, representing perhaps 75% of all wells drilled since 1965. Water Well Records reports were published by the Nova Scotia Department of Mines between 1965 and 1971 and by the Nova Scotia Department of the Environment between 1972 and 1978. Records for 1979 are stored for computer manipulation. Records between 1980 and 1985 are organized and filed for reference but are not yet on computer records for direct access. In 1986 some 41 000 people served by municipal systems relied on groundwater as did some 380 000 rural residents (Tables 2.2 and 2.3). Provincial officials familiar with the water supply situation and groundwater use estimate that, in 1987, very few, if any, municipal systems relied on shallow wells. However, approximately 145 000 rural residents depended on

shallow wells for their domestic supply. Shallow wells are common throughout the province, with concentrations reported in Lunenburg, Shelburne and Yarmouth counties.

2.3.4 New Brunswick

Groundwater management is the responsibility of the Water Resources Branch of the Department of Environment.

The comprehensive review of the publication prepared for the Atlantic Development Board (see Section 2.3.1), provided a detailed evaluation of New Brunswick. In the summary report, the following statement is made: "Bedrock and overburden aquifers in New Brunswick contain large volumes of essentially untapped groundwater. Carboniferous rocks comprise the best bedrock aquifers. Extensive overburden deposits are found along the major rivers in New Brunswick and are suitable for large groundwater supplies"[11]. The reports for each region of the province include summaries of some 122 bedrock wells, of which approximately 50% are less than 15 m deep. Some 35% of the 46 recorded overburden wells are also shallower than 15 m. The report includes a map locating the largest aquifers in overburden deposits which should help to define areas where shallow wells can be expected[16].

New Brunswick is very complex geologically. Pennsylvanian sandstones dominate along the eastern coast, opposite Prince Edward Island, while older and less permeable structures dominate along the Bay of Fundy and in the north. Water resources reviews have been prepared by Department staff for all seven planning regions, as listed in Table 2.6. These reports summarize and interpret available information but place little emphasis on groundwater, particularly in the earlier reports. However, each report includes a hydrogeological map of the region. A review is provided for each of the community water supply systems. Hardly any information is presented on rural water supplies. The water chemistry of municipal supply wells in New Brunswick has been investigated by the Department of the Environment[23].

Regulations issued in 1983 under the Clean Environment Act require well drillers to be licensed and to file reports on all wells[24,25]. Such well records have been required since 1973 (under earlier regulations) and are filed with the Water Resources Branch. Some 10 000 well records were obtained between 1973 and 1981 and a further 10 000 since 1982. The management of groundwater data is computerized but the system is not completed. Dug wells are subject to certain requirements concerning water quality protection under the regulations but neither individuals nor contractors who dig the wells are licensed and no records are required to be kept. Hand-drilled wells of small diameter, which typically penetrate up to 10 metres and are equipped with handpumps, provide domestic water supplies to many rural residents in the northern part of the province. No records exist of this type of well.

Table 2.6
Water Resources Reviews in New Brunswick

Report No.	Planning Region	Report Date
I-7702	Saint John	October, 1977
I-7901	Bathurst	June, 1979
I-7902	Campbellton-Dalhousie	July, 1979
I-8001	Fredericton	August, 1980
I-8104	Edmundston	September, 1981
I-8401	Newcastle-Chatham	December, 1984
I-8402	Moncton	December, 1984

The NHRI report (Table 1.4) estimated that, in 1981, over 135 000 people served by municipal systems relied on groundwater, as did over 314 000 rural residents. Provincial officials familiar with the water supply situation and groundwater use believe that in 1987 there were approximately 100 000 wells throughout the province, providing groundwater to about 65% of the total population. Records are available for only about 20% of these wells (only those drilled since 1973). A rough estimate suggests that up to 20 000 shallow wells exist, serving perhaps half of the rural population, as well as an unknown number for municipal systems. Areas where substantial numbers of dug wells are reported to be common are north of Shepody Bay, east and south of Fredericton, the Sussex area and the area northeast of Bathurst.

2.3.5 Quebec

In Quebec, groundwater is managed by the "Ministère de l'Environnement du Québec(MENVIQ)". Since 1954, the government of Quebec has promoted the use of groundwater by providing technical assistance to small municipalities who have had water supply problems. To date, more than 1000 preliminary hydrogeological study reports have been produced by the "Direction des eaux souterraines et de consommation du MENVIQ". The Branch has also produced a dozen reports on detailed hydrogeology studies conducted in response to solving water supply problems. Hydrogeology inventory reports have also been produced for each of the basins flowing into the St. Lawrence between Montreal and Quebec City. These reports include maps which identify the location of the major groundwater users, principal aquifers, sources of potential contamination, and major chemical ions. In 1979, the Branch published a study of water quality taken from bedrock. An additional source of information on wells is from well drilling records. Since 1967 all drillers have had to be licensed and to submit reports on all wells drilled.

The ministry created a computerized hydrogeological data bank in 1972 which included data from well drillers' reports, groundwater studies and geophysical surveys. As of 1986, the data bank contained approximately 100 000 files[26]. This data bank however does not include any information on dug wells and provincial officials are unable to estimate their numbers. To ensure the protection of wells and underground water, the ministry has published a set of guidelines for well construction. A mapping program which will show vulnerable aquifers and a guide on how to protect the perimeters of these areas will be published shortly. In 1980 a groundwater monitoring network was established.

It is estimated that in 1986 some 1 263 000 people served by municipal systems relied on groundwater, as did some 325 000 rural residents on private systems (Tables 2.2 and 2.3).

2.3.6 Ontario

Ontario is the most populous province and has more people dependent on groundwater drinking water supplies than any other province. Water resources including groundwater are managed by the Water Resources Branch of the Ministry of the Environment, with headquarters in Toronto and six regional offices (Toronto, Sudbury, Thunder Bay, Kingston, London and Hamilton). Controls over groundwater extraction date from 1947, at which time drillers were first required to provide well logs to the provincial authority (formerly the Ontario Water Resources Commission). Compliance by well drillers was poor in the early years but is good now. Permits for all water wells are required and contractors must be licensed under the Water Resources Act (Section 22), including contractors who dig shallow wells, those who bore large diameter wells and those who drill wells[27].

A wealth of information on groundwater within the province is summarized in a publication[28] intended for the general public. There are dozens of reports which outline the water resources of various river basins. Maps showing groundwater probability exist for many counties and regions. A useful index is available, listing various types of maps throughout the province for community planning[29]. There is a total of more than 320 000 water well records which are maintained in summary form on a computerized system. Until 1983 these records were published as bulletins for the various regions of the province. Since then, however, hard copy is provided on request for wells in a given locality but comprehensive summaries are no longer published because of the massive quantities of data. There are some 35 000 wells in York County, for example, and some 46 000 in Durham County. In 1987, 15 911 new wells were recorded according to provincial officials.

The ministry has carried out a number of internal studies on groundwater, mostly related to potential aquifer contamination from polluting sources such as waste disposal sites, acid rain and well pumps. Researchers at the Institute for Groundwater Research in Waterloo are also studying groundwater quality and potential contaminants, including a current investigation into the impact of acid rain on sandy soils in the vicinity of Sudbury[30].

Although most Ontario urban centres are served by piped water supply systems (Table 1.5), there are still many small towns and villages which lack municipal systems. Most of them rely on groundwater and the quality of water in the individual wells frequently results in complaints. The first step in responding to these complaints is to carry out a sanitary survey which documents and examines the various wells in the locality, including water quality tests. If tests confirmed the perceived problem, the Ministry of Environment has, under a program in existence since 1978, assisted the local government to engage consultants to analyze the situation and propose remedial measures. Some 200 to 250 such studies, as the one for the village of Spencerville[31], have been completed since 1978, containing information on the location and water quality of many thousands of wells. However, this information has not been summarized. A consulting hydrogeologist with extensive experience from groundwater investigations of 27 smaller towns in Ontario estimates that there are hundreds of thousands of water wells in the eastern part of the province and that from 25% to 75% of them are contaminated from various sources, including septic tanks, agricultural sources, road salt, and small hydrocarbon spills[32].

Despite the abundance of data on groundwater throughout Ontario, provincial authorities have provided a summary table of the breakdown of wells by 3 depth levels for 53 counties for a total of 256 292 wells; 4.3% are less than 7.5 m, 23.9% are between 7.5 m and 15 m, 71.8% are >15 m[33]. In 1986 some 1 320 000 people served by municipal systems relied on groundwater as did some 1 300 000 rural residents (Tables 2.2 and 2.3). Provincial officials familiar with the water supply situation and groundwater use estimate 50 municipal systems relied on shallow wells and that 520 000 rural residents relied on water from private shallow wells (Tables 2.2 and 2.3). The principal areas where shallow wells are common are located south of the Canadian Shield and in scattered pockets in Northern Ontario.

2.3.7 Manitoba

Groundwater has long been an important source of water in Manitoba, particularly in the rural areas. The Municipal Act was modified by the provincial legislature in 1898 to allow the municipalities to drill water wells on new farms. Between the years 1923 (when the provincial drilling program ceased) and 1963 (when the Ground Water and Water Well Act was passed) there was no need for well drillers to submit records to the provincial authorities. However the Department of Natural Resources has compiled well drilling records since 1963 and now has about 50 000 logs of wells drilled in the past 23 years (1963–1985). The format of the well drillers' report is outlined in the 1973 regulations of the revised Ground Water and Water Well Act[34]. The well logs were retained in a card system, manually sorted from 1963 to 1973. From 1973 to 1986, in addition to the card system, all well logs were computerized to facilitate annual compilations of well records. In 1987, entering well data in the card system was discontinued and the well records, since then, are entered only in the computerized system. Each year from 1963 to 1987, the Department of Natural Resources published a summary of all records on a geographical basis. This annual summary was also discontinued in 1987. The 1984 summary of 2637 well records, for example, noted that 50% of the wells were intended for domestic water use. The average well depth was about 28 m and 48% were drilled in sand and gravel aquifers[35]. These data indicate that a high percentage of these wells could probably be classified as shallow, or less than 15 m deep. Entering of the data on a computer-based system now permits the retrieval of various document formats such as by location, year, owner, etc...

The Prairie Farm Rehabilitation Administration (PFRA) has existed since 1935 to assist farmers in Western Canada. Between 1973 and 1987, PFRA programs have helped to install 13 846 water wells in Manitoba. Although 42.5% of PFRA-assisted wells were large diameter (usually 76 cm) and shallow (averaging less than 15 m in depth), the trend is towards deep, small-diameter wells. Further information on PFRA programs is provided in Annex 5. PFRA officials were kind enough to provide computer plotted maps, covering the period 1979/80 to November 1986 of dugouts, domestic wells <30 m and all domestic wells[36,37,38,39].

The Manitoba Water Services Board under the authority of the Department of Agriculture Act administers the Agri-Water Program assisting individual farmers. The Agri-Water program has published a Farm Water Source Potential Map which identifies the various types of aquifers throughout the province and indicates where good prospects exist for shallow and bedrock wells. This map indicates that groundwater is unavailable or of poor quality in many areas of Manitoba, including generally the area southwest of Winnipeg between the Red and Assiniboine rivers. In areas where community water supplies do not serve rural residents and groundwater prospects are poor, many farmers have to rely on tanker trucks to bring their drinking water from better sources. Tank loading facilities have been developed with high-capacity water points. A total of 132 such tank loading facilities have been built, of which 86% are supplied by wells. Agriculture officials estimate that only 20% of the water supplied from these facilities is used for domestic purposes.

The Water Resources Branch of the Department of Natural Resources has prepared a series of 13 maps of groundwater availability at a scale 1:250 000 which cover most of the populated areas in the province[40]. For each region the set of maps shows bedrock and surficial geology, locates known water wells and provides data on chemical analyses of water samples, including pH. A useful map has also been produced of the groundwater potential of southern Manitoba at a scale of 1:2 000 000[41]. Maps have been prepared recently to reflect soils and geological sensitivity to acidic deposition in Manitoba. One map rates soils, surficial and bedrock geology for their potential to reduce incoming acid deposition prior to its entry into aquatic ecosystems. These maps indicate areas of high sensitivity to acidic precipitation on the east side of Lake Winnipeg and the northwest corner of the province, areas in which very few people live. The populous agricultural areas of the province are less sensitive, mainly because the overlying soils can buffer the acid deposition[42].

Researchers have investigated groundwater conditions extensively in the Pinawa area along the Winnipeg River as part of radioactive waste management research[43]. Extensive geological and hydrogeological data which are available for this region should make this site of special interest for longer term studies of chemical changes in groundwater quality. Provincial maps were prepared in 1986 to show nitrate levels, above and below 10 mg/L NO_3^-[44], the maximum acceptable concentration according to Canadian guidelines[45].

In 1987 some 71 000 people served by municipal systems relied on groundwater, as did some 212 000 rural residents (Tables 2.2 and 2.3). Provincial officials familiar with the water supply situation and groundwater use estimate that in 1987 some 6700 people served by nine municipal systems relied on wells installed in unconfined aquifers and that some 22 000 rural residents relied on water from private shallow wells in unconfined aquifers[46]. The principal areas where wells in unconfined aquifers are common include the sandy areas around Carberry and Oak Lake. Fairly extensive unconfined aquifers are also common in the Portage la Prairie, St. Claude, Morden, Minitonas–St. Lazare, and Glenella–Plumas areas. Numerous smaller unconfined aquifers occur in the southern part of the Province. For the purpose of this report, unconfined aquifers in Manitoba have been grouped together in the "shallower than 15 metres" category.

2.3.8 Saskatchewan

2.3.8.1 Water Administration Overview

The management and administration of all surface and groundwater resources is the responsibility of the Saskatchewan Water Corporation. Under its mandate the corporation oversees the planning, development and allocation of all water resources in Saskatchewan; the operation and maintenance of major reservoirs; and, the upkeep of the provincial water rights data base. Other agencies involved in the water resource field are the Saskatchewan Research Council, providing regional groundwater mapping and scientific research; the Prairie Farm Rehabilitation Administration, extending federal financial and technical assistance to the rural and farm population; and the Prairie Province Water Board, dealing with interprovincial water management issues.

2.3.8.2 Data Bases

Baseline groundwater information is available from both the Saskatchewan Water Corporation and the Saskatchewan Research Council. The Saskatchewan Water Corporation maintains and updates computerized records and microfiches of 56 425 water wells and 27 108 test holes drillers' reports[47].

The Saskatchewan Research Council maintains and updates groundwater maps and geologic maps of Saskatchewan[48], computerized water quality records of over 3000 wells, and information and data related to past and present research in the groundwater field.

The Prairie Farm Rehabilitation (PFRA) has helped install 25 088 wells for farmers in Saskatchewan. Some 60% of these wells were large diameter (typically 76 cm) and shallow, averaging less than 15 m in depth, but the trend is toward deep, small-diameter wells. Further information on PFRA activities is described in Annex 5. PFRA were kind enough to provide computer plotted maps covering the period 1979/80 to November 1986 of dugouts, domestic wells <30 m and all domestic wells[36,37,38,39].

2.3.8.3 Groundwater Use and Wells

With Saskatchewan's semi-arid prairie climate, its residents living away from the major river system rely strongly on drought-proof supplies of groundwater to meet their domestic needs. Provincial estimates suggest that 90% of all rural users, as well as 70% of all Saskatchewan communities, rely on groundwater.

In an effort to minimize the risk from droughts, there has been a trend towards developing deeper wells in Saskatchewan. Based on the Geological Survey of Canada well inventory between 1936 and 1947, 72% of all wells were less than 15 m in depth. Saskatchewan Water Corporation estimates suggest only 44% of wells in use today are less than 15 m in depth and only about 30% of wells constructed today are less than 15 m deep. However, the trend to deeper wells is countered by water quality. Water quality generally decreases with depth, forcing a tradeoff between drought resistance and potability. A computer search of Saskatchewan Water Corporation's water rights records shows that of all municipal licences (usually only for allocations greater than 15 000 m^3/year), 1377 use groundwater (Table 2.7). About 38% of these licensed groundwater projects are considered shallow and draw water from less than 15 m deep.

Table 2.7
Licensed Municipal Groundwater Rights in Saskatchewan

No. of Wells	Reported Depth	% of Total
151	na	11
469	0 to 15m	34
757	Greater than 15 m	55
1377	Total	100

Note: na = not available
Source: 49

In 1987 some 222 000 people served by municipal systems relied on groundwater as did some 230 000 rural residents (Tables 2.2 and 2.3). Provincial officials familiar with the water supply situation and groundwater also estimate that approximately 50 000 people served by 93 municipal systems, in addition to the roughly 230 000 rural residents, relied on shallow wells. Shallow wells are common throughout the province south of the 54th parallel but are reported to be less common in the west central and southwestern portions.

2.3.9 Alberta

2.3.9.1 Background

The most comprehensive collection of hydrogeologic information in Canada is probably that from Alberta. The Research Council of Alberta started field studies in 1930. The Groundwater Division of the Research Council of Alberta was formed in 1955 and groundwater data files were established in 1957. These consisted of water well drillers' logs, Research Council's technical summaries and routine water analyses supplied by the various provincial laboratories[3]. Hydrogeological reconnaissance mapping was started in 1968. Some 47 maps have been produced, each map portraying groundwater conditions and their controlling factors, and providing an overview of these conditions in each area[50]. Revision of the Ground Water Control Act in 1970 led to a report submission of over 80% from less than 50% and provided more basic information[3].

Upgrading of legislation in 1981, with the adoption of the Ground Water Development Act, streamlined administrative procedures and strengthened the enforcement sections dealing with report submission and well construction. It also places responsibility on the drilling firm to know the geology and groundwater conditions and for the control of flowing holes[3].

The Earth Sciences Division of Alberta Environment has been maintaining water well records since 1982.

2.3.9.2 Groundwater Data Sources

There are now some 300 000 well logs in the files maintained by the Groundwater Resource Information Service (GRIS), Earth Sciences Division of Alberta Environment. These incorporate the old records provided by the Geological Survey of Canada during the first part of this century, including the massive groundwater inventory of wells undertaken in 1935.

Over 7000 new drillers' reports are being added to the GRIS file each year in the format outlined in Annex 2. The legislation and regulations do not require any information to be provided about dug wells. However, because the file obtains all chemical analyses from the provincial laboratory, some dug wells are added when a water analysis is obtained.

Between 1973 and 1986 the Prairie Farm Rehabilitation Administration (PFRA) helped install 34 882 wells for farmers in Alberta. Some 19.7% of these wells were of large diameter (typically 76 cm) and relatively shallow, averaging from 15 to 20 m in depth but the trend is toward deep small diameter wells. Further information on PFRA activities is described in Annex 5. PFRA officials were kind enough to provide computer plotted maps covering the period 1979/80 to November 1986 of dugouts, domestic wells <30 m and all domestic wells[36,37,38,39].

Alberta Environment also prepares hydrogeologic X-sections throughout the province such as for NTS 72M[51]. The department receives reports submitted on most resource development projects. In most cases the reports contain information on new well(s) with at least a 24 hour pumping test and chemical analysis. All reports are microfilmed, added to the bibliography and filed according to land location[3].

The Engineering Branch of Alberta Agriculture has compiled over 5700 data entries on chemical water analysis reports of farm water supplies. Over 80% of the data base are related to private wells. The data, which do not include well log information, are stored on computer and can be identified by the farmer's name and legal description.

Alberta Environment, in co-operation with the local health unit, offers a water analysis service to all residents in the province. Over 10 000 routine water analyses are provided

each year under this program and all analyses of groundwater are added to the relevant well data file. This information is supplemented by well surveys, water diversion reports, and reports related to the solving of groundwater problems[3].

A major program of basic data gathering is being conducted by Alberta Environment. This program has gathered new data from many sources and adds approximately 150 new test holes and pumping tests, undertaken by department equipment, to the file every year. In addition to this general program, detailed water level records on over 250 wells in the four Observation Well Networks have been grouped as follows: Provincial, Oil Sands, Local, and High Quality Chemistry.

a) The Provincial network, which has 130 wells and proposes to expand to 200 wells in 1988, provides background water levels and chemistry throughout the province and monitors any changes.

b) The purpose of the Oil Sands network, which was composed of 50 wells in 1986, is to obtain background water level and chemistry data in the vicinity of major surface oil sands development and to monitor changes in water levels.

c) The Local network (20 to 40 wells) monitors changes in water levels and chemistry associated with water storage, diversion or other activities caused by human endeavours.

d) The High Quality Chemistry network is designed to collect supplementary information about groundwater quality of important aquifers in the province. Information will be added to water level and aquifer data currently available from the existing observation well networks. A total of 33 wells and springs have been selected for sampling in 1986. These sampling points include 22 observation wells, four flowing wells and seven springs. Each year several additional wells will be included and some wells which do not meet the objectives will be excluded. An appropriate sampling, preservation and analysis protocol has been developed to ensure high quality results. A total of 30 parameters are monitored. In the field, nine of the parameters (pH, Eh, EC, Dissolved Oxygen, Total Fe, Sulfate, Alkalinity, Hardness and Temperature) are determined in a mobile laboratory. Several additional high quality wells will be installed and fitted with dedicated pumps to minimize cross-contamination. Samples obtained from these high quality wells will be analyzed for trace organics in addition to those 30 parameters.

This type of sampling will be expanded until all wells in the provincial network are included. After an initial period of sampling every six months, to determine stable background levels, the sampling interval will be lengthened to one year on water table wells and two years on confined aquifer wells[3].

2.3.9.3 Groundwater Data Storage and Handling

All information concerning individual wells is filed according to land location. An index of those files is compiled and is available in paper printout (7350 pages) or 28 fiche (270 frames each)[52]. All groundwater reports are stored by author-date-title. A bibliography of these reports is available in paper printout (800 pages or 15 fiche) by author-date-title or by 1:250 000 map sheet. The processing of data, from the time the information is taken in the field to the final certified printout, takes approximately 70 days. Microfilming of the updates is done twice a year, with new update microfiche available in mid-February and mid-August. All well hydrographs are digitized, using a Wang PC and Numonic Digitizer and filed by land location.

An in-house computer, included in the 1987/88 budget, would enable on-line interaction with the index, reduce operating costs significantly and provide direct access by outside users. The index would be expanded to include details on chemistry and aquifer tests which will increase the effectiveness of the system. Direct transfer of chemical data from the Alberta Environmental Centre Laboratory at Vegreville should be completed in the near future. Data will be accessible in machine-readable format and will, after approximately 10 years, provide a reasonable chemistry base for Alberta (over 100 000 records plus records from chemistry network)[3].

2.3.9.4 Municipal and Rural Water Supplies

The Pollution Control Division of Alberta Environment prepares a facilities survey each year of municipal water and wastewater systems throughout the province. The 1986 survey reports about 2 million people are served by 655 public water supply systems of which 412 communities have distribution networks. Considering all of the systems, 362 of these supply only groundwater. The provincial population totalled some 2.4 million in 1986, and approximately 360 000 people are served by individual systems. Of the 360 000 people which are not served by municipal systems, an estimated 315 000 are served by individual wells or rainwater catchment systems (Table 2.3). In 1987, approximately 274 000 people were served through municipal distribution networks as shown in Table 2.2. In total, there are some 589 000 people in Alberta reliant on groundwater resources or rainwater catchments for their water supplies.

2.3.9.5 Shallow Well Users

Data management systems currently available to provincial authorities have the capability to prepare a systematic analysis of the number of people who obtain their drinking water from shallow wells. An analysis of records in the data files indicates that 20.7% of all wells drilled in Alberta are less than 15 m deep. This indicates that approximately 90 000 people on private systems use shallow groundwater or rainwater catchments. The municipal population reliant on wells shallower than 15 m is not reported. However, the number is thought to be low. The principal areas where shallow wells are common are the Peace River Block–North of Grand Prairie area, West of Edmonton in acreage area, Cold Lake–Fort McMurray, and Medicine Hat.

2.3.10 British Columbia

Reliable assessments of groundwater use in British Columbia are difficult to obtain because it is not mandatory for well owners or drillers to register water wells and their use, nor is it a requirement for well drillers to be licensed. Well records are supplied to the Ministry of Environment on a voluntary

basis and some 60 000 such records are on file; this file increases by about 2500 wells each year. Wells for which records are available are plotted on some 750 water well location maps, generally at scales of 1:12 000 and 1:16 000. Well records are collected and processed by ministry staff in regional offices and are maintained by the ministry's Groundwater Section on files in Victoria. The ministry maintains a network of 143 observation wells to monitor changes in groundwater levels and trends in water quality. These observation wells are located primarily in areas where groundwater is used extensively for potable water supplies and for irrigation purposes. Data from the observation well network is manipulated by computers and has been published periodically. Systematic water quality analyses were initiated in 1972 on this network. The data is being analyzed (3740 analyses on file) to identify problems or answer concerns; over 375 overlays of well location maps have been prepared[53].

The major aquifers in the populated areas of the province are generally known and have been documented[54]. In 1986 some 189 000 people served by municipal systems relied on groundwater as did some 295 000 rural residents (Tables 2.2 and 2.3). Provincial officials familiar with the water supply situation and groundwater use estimate that in 1986 some 50 000 people served by 11 municipal systems relied on shallow wells for at least part of their water supply. It is not known how many residents relied on water from private shallow wells.

2.3.11 Yukon

There were about 24 000 residents in the Yukon in 1986, but officials in the local government estimate the 1987 population to be closer to 27 300. All but some 1000 people live in 19 urban centres, for which water supply information is summarized in Table 2.8. The largest centre is the capital, Whitehorse, which uses both drilled wells and surface water[55].

The two main drillers in the Yukon maintain records for their own purposes but are not required to provide well logs to the government. Well records are retained by the municipalities but are not retained centrally. Licenses are required for water withdrawals in excess of 2500 gallons (11.34 cubic metres) daily under federal legislation (Northern Inland Waters Act) but smaller wells require no such license.

In 1986 some 19 000 people served by municipal systems relied on groundwater, as did some 750 rural residents. Data in Table 2.8 suggest that some 2400 people in four communities (Carmacks, Dawson, Keno and Ross River) get some or all of their water from shallow wells. If it is assumed that 50% of the 1000 people living outside the centres listed in Table 2.8 use shallow wells, the total population in the Yukon which gets its drinking water from shallow wells would be about 2900.

2.3.12 Northwest Territories

A comprehensive review of community sources in 1982 is summarized in Table 2.9 which shows that the population using groundwater in these five communities totalled less than 700 and that most use other sources as well. Fewer people in the Northwest Territories use groundwater as their water source than in any other province or territory. Surface water is abundant and geological conditions are such that little groundwater is practically available, except in the southwest portion of the Territories. The review of community service systems noted that several communities had attempted to use wells for drinking water in the past but the wells had been abandoned. This was the situation in Fort Resolution (14 wells were drilled but had not produced good potable water), Pine Point (Cominco drilled deep wells in 1963 and 1968 and introduced reverse osmosis treatment in 1972 but subsequently used Great Slave Lake as the source), Rae-Edzo (wells had insufficient capacity) and Fort Norman (water quality from a well drilled in 1970 was unsatisfactory)[57]. Water licenses are not required, except for large water withdrawals (as in the Yukon). Drillers are not required to submit well records to the government and there is no centralized record of existing wells. There are no drilling companies based in the Northwest Territories.

The NHRI report (Table 1.4) estimated that 1% of the urban and rural population relied on groundwater, or 282 people in total. However, the information in Table 2.9 suggests that up to three times this number of urban residents may get some of their water from groundwater during part of the year. Officials from Indian and Northern Affairs in Yellowknife estimate that about 200 people out of about 700 rely on groundwater where groundwater is part of their sources. About 46 000 people obtain their water from municipal systems.

Table 2.8
Water Supply Information for Communities in Yukon

Community	Population Total (× 100)	Population % Served	Water System	Main Water Source	Remarks
Beaver Creek	1.0	80.0	N	Drilled Wells	Individual water supplies
Burwash Landing	0.7	100.0	N	Surface	Water distributed by truck
Carcross	3.0	100.0	N	Drilled Well	Water distributed by truck
Carmacks	4.1	61.0	N	Shallow Well	Individual water supplies
Dawson	15.5	87.1	Y*	Shallow Wells and river intake	River intake seldom used
Destruction Bay	0.8	40.0	Y*	Drilled Well	
Elsa	3.8	92.1	Y*	Surface	
Faro	11.0	100.0	Y*	Drilled Wells	
Haines Junction	5.3	84.9	Y*	Drilled Well	
Keno	0.4	100.0	N	Shallow Dug Well	Water distributed by truck
Mayo	5.0	90.0	Y*	Drilled Well	
Old Crow	2.6	100.0	N	Drilled Well	Water distributed by truck
Pelly Crossing	2.1	95.2	N	Drilled Well	
Ross River	4.0	87.5	N	Shallow Dug Well	Water distributed by truck
Stewart Crossing	0.2	100.0	N	Drilled Well	
Teslin	4.0	93.8	N	Surface Water	Water distributed by truck
Upper Liard	1.0	na	N	na	
Watson Lake	16.0	56.3	Y*	Drilled Wells	
Whitehorse	184.0	89.7	Y*	Drilled Wells & Surface	Warmer water from wells is used more in winter

Notes: Y = Yes, N = No, * = pump house (Selkirk for Whitehorse), na = not available.

Source: 55,56

Table 2.9
Communities Using Groundwater in the Northwest Territories

Community	Population	Remarks re Sources
Enterprise	46	Private wells. Also some water trucked from Hay River.
Fort Liard	342	Dug and drilled wells. Also some water trucked from Petitot River.
Jean Marie River	49	Dug wells and the Jean Marie River.
Nahanni Butte	94	Dug well at school. Also rainwater catchments and Bluefish Creek in summer. South Nahanni River in winter.
Wrigley	137	Two new wells drilled in 1975. Water delivered by truck.

Note: None of these communities has a piped water system.

Source: 57

3. Drinking Water Supplied by Precipitation Catchment Systems

3.1 General

Precipitation catchments are systems built to catch and supply atmospheric water under its different forms for a multitude of purposes, including drinking water. Natural surficial water such as that from rivers and lakes and large reservoirs created by major dams is excluded from consideration here. Precipitation catchments, for the purposes of this study, are small scale systems built primarily for domestic and farm water supplies, usually in rural areas. There are two basic types of precipitation catchment systems used for drinking water in Canada. The roofs of houses and possibly other buildings (garages or barns) provide one type of catchment, principally for farms but occasionally for cottages. Water is conveyed from the roof to a reservoir, beside or inside the building where it will be used. Many old farmhouses have a cistern in the basement for storing precipitation. Another type of catchment, more common in the prairie provinces, consists of a "dugout". A tank is excavated in the ground, and in some cases the excavated material is used to form part of the sides of the reservoir. The dugout is sited so that runoff from as large an area as possible will flow into storage. Most of the runoff in dugouts is obtained from snowmelt. The amount of water which can be captured depends upon the catchment area and local patterns of precipitation. Annual precipitation varies greatly across Canada, from less than 100 mm in the western Arctic to more than 3000 mm in the coastal mountains in British Columbia. A building with a roof area of 60 square metres, typical for a modest farm house, could catch up to 72 cubic metres of water annually in areas receiving 1200 mm of precipitation per year, such as many parts of the Atlantic provinces. This quantity of water could theoretically supply a family of four people with almost 50 litres each, daily, throughout the entire year.

Water quality from precipitation catchment systems depends on the quality of the precipitation, the nature of the catchment area and the method of reservoir storage. Roof catchment systems generally provide water of better quality than ground catchments. Most suspended solids in the precipitation will settle out if the water is left undisturbed long enough in the reservoir. The water can also be treated by small scale systems of filtration, disinfection and chemical adjustment.

Although not widely used for rural water supplies within Canada, precipitation catchment systems have been researched extensively and widely promoted for use in countries around the world. Researchers have pursued the topic recently at three Canadian universities in Alberta, Ontario and Nova Scotia. A useful overview report on the technology has been published by consultants working for the U.S. Agency for International Development[1]. Training materials including slide-sound modules which describe the system and report on a case study were produced by Canadian consultants and are available from the World Bank[2]. Research on this topic has also been sponsored by the Ottawa-based International Development Research Centre[3].

3.2 National Overview

Precipitation catchments are not a well documented form of water supply in Canada. Few government agencies seem to be aware of research on precipitation catchment systems for domestic water supply. An estimated 20 000 permanent residents in British Columbia, 4000 in Manitoba and 1000 in Nova Scotia rely on precipitation catchment for their drinking water supply (Table 2.3). PFRA estimates some 70 000 people are dependent on dugouts to supply at least a portion of the Prairie population's drinking water. Records of use of precipitation catchment by cottagers and campers, indicated in Table 2.4, is virtually non-existent. An estimated 1000 vacationers in both British Columbia and Nova Scotia rely on such systems for their source of drinking water. The most intensive use of rain catchment systems is in the prairie provinces, where PFRA has helped build some 114 873 dugouts in the past 52 years, although 67% of all dugouts are used exclusively for livestock watering. Areas in which there is extensive use of precipitation catchment systems for household or household and livestock use for the prairie region are indicated in Map 4. Provincial officials in Ontario say there could be tens of thousands of precipitation catchment systems in use. Data from a 1961

survey on the sources of farm water supply for household and livestock use (Table 1.6) indicate that there may indeed be substantial use of precipitation catchment systems.

3.3 Provincial/Territorial Overview

3.3.1 Nova Scotia

The Department of Health has produced a booklet on precipitation systems that provides basic information for dimensioning the cisterns and enhancing water quality[4]. The following statements are made: "Precipitation in Nova Scotia is relatively acidic, a fact to remember in selecting construction material" and "Precipitation... used for most domestic purposes... should not be for drinking water... will require adequate treatment before usage".

The number of precipitation catchment systems throughout the province apparently totals less than 250. Approximately 1000 people in rural areas rely on this source of supply. In addition it is estimated 1000 vacationers rely on precipitation catchment systems. The largest concentration is in Hants County, where groundwater is of poor quality. Other precipitation catchments are located near Little Narrows in Cape Breton and near Bedford, Peggy's Cove and Dover. These systems are only used where groundwater is unavailable or of poor quality.

3.3.2 Newfoundland, Prince Edward Island, New Brunswick and Quebec

No information is available concerning precipitation catchments in any of these four provinces. It is assumed that their use is minimal. In Prince Edward Island precipitation catchments are reportedly used for livestock only.

3.3.3 Ontario

Precipitation catchment systems are used extensively to supply rural residents in certain areas where piped water systems do not exist and where groundwater is of poor quality. In the Niagara Peninsula, much of the groundwater is highly mineralized and as many as 70% of the farmsteads and rural homes in that area have cisterns to supply some or all of their domestic water needs. Water is trucked from municipal systems to replenish the cisterns if insufficient water is provided from precipitation. A substantial trucking industry exists to supply water to rural households.

Precipitation catchment systems are also reported to be common in several other regions, including the southwest counties (Kent, Essex and Lambton) and in areas north of Toronto. Records on the extent of use of precipitation systems apparently do not exist, although some officials suggest there may be tens of thousands in use. Farm ponds, providing storage up to four months, also exist in areas using precipitation cisterns for domestic supplies.

Research under way at the University of Ottawa indicates that a number of farms in southeastern Ontario depend on precipitation catchments where local groundwater is excessively hard. Some new homes are apparently being built to incorporate both solar heating and precipitation catchments in an effort to supply the residents' utility needs as independently as possible[5].

3.3.4 Manitoba, Saskatchewan and Alberta

The prairie provinces have many similar characteristics and so are treated together. The tradition whereby farmers rely on snowmelt from spring runoff for some or all of their water supplies is long-standing in many areas. If shallow or deep wells could not provide sufficient water, farmers have had little option but to utilize spring runoff in catchment systems.

All provinces have engineering services to help farmers develop their water sources. Saskatchewan, which has the highest percentage of farm population (18.2% of total population — see Table 1.2) has the longest established service unit, going back some 25 years. The Agri-Water Program, under the authority of Manitoba's Department of Agriculture Act responsible for assisting farmers with their water supplies, has produced the "Farm Water Supply Potential Map" to show areas where dugouts are recommended, based on local groundwater potential. This map also shows the annual runoff exceeded 90% of the time and states the runoff areas required to fill a dugout (61 m x 21 m x 4.3 m deep) in 9 years out of 10.

Since its establishment in 1935 the Prairie Farm Rehabilitation Administration (PFRA) has helped construct some 114 873 dugouts in the prairie provinces: 21 561 in Manitoba, 63 330 in Saskatchewan and 29 982 in Alberta. Further information is provided in Annex 5. Although some of these dugouts may have gone out of service, having become silted or made redundant by the development of other water sources, it is likely that most farms utilize dugouts to supply at least part of their water requirements, particularly if they have livestock. Since 1983, 67% of all dugouts assisted were strictly for livestock use. The number of people using these dugouts for drinking water is difficult to establish. However knowledgeable officials in PFRA estimate some 70 000 people are dependent on dugouts to supply at least a portion of their drinking water. PFRA publishes general information on dugouts for farm water supplies and also provides both technical advice and financial assistance for the construction of dugouts[6].

PFRA has a data bank identifying the locations of PFRA dugouts constructed for household or household and livestock use from 1979 to present. Maps, at a scale of about 1:3 000 000, illustrate the locations of use for most of the Prairie Region. In areas where information is not plotted, the raw data is available in a tabular format. Examinations of these maps indicate most of the dugouts are located in the Peace River–Grande Prairie and Lethbridge areas in Alberta, the south central and southeastern areas in Saskatchewan, and the area southwest of Winnipeg in Manitoba. Because information has not been completely plotted for Manitoba, it is not known if there are any other areas of significance. Provincial data from Manitoba, however, indicate that about 4000 rural residents rely on precipitation catchments for their source of drinking water.

3.3.5 British Columbia

Precipitation catchment systems do not appear to be common in British Columbia despite the fact that the climate makes it the most appropriate region in the country for such systems. In coastal regions precipitation is abundant and temperatures are moderate so frost problems are minimal[7]. Statistics from the British Columbia Ministry of Environment indicate approximately 20 000 permanent and 1000 non-permanent residents rely on cisterns for their water supply. In recent years the Ministry of Environment has received about a dozen inquiries from residents of the Gulf Islands (between Victoria and Vancouver) for information on practical ways to collect and treat precipitation. There is no formal program to assist residents in development of private catchments. However, information on individual water systems is available from the provincial Ministry of Environment[8].

3.3.6 Yukon and Northwest Territories

The limited precipitation and the cold climate of these regions make the territories the least appropriate areas in Canada for precipitation catchment systems. Hardly any such systems have been reported. One exception is the reference to "homemade rainwater collectors" observed to meet some of their summer water requirements in the small community of Nahanni Butte (approximate population of 100) near the junction of the South Nahanni and Liard Rivers in the southwest portion of the Northwest Territories[9].

4. Findings and Conclusions

There are large numbers of people in all parts of Canada who rely upon groundwater for domestic supplies. The estimates presented herein and summarized in Table 4.1 are considered to be as representative of the situation with respect to use of groundwater as is possible at this time. It is estimated that over 2.0 million (7.9%) of the 1986 population in Canada are dependent on shallow wells and that over 6.9 million (27.4%) of the 1986 population rely on groundwater for domestic use. In addition, there is significant use of groundwater to serve the needs of cottagers, campers and tourists. There is also significant reliance on rainwater catchments in certain areas. As described in Chapter 2, the distribution of groundwater use is widespread except in the northern territories. Precipitation catchments are most common in the prairie provinces and in parts of southwestern Ontario.

There are a variety of potential risks of contamination of groundwater supplies which have been identified from experience. The majority of such risks are generally restricted to particular land use activities and confined to local aquifer contamination. However, Health and Welfare Canada is concerned about the potential risk of contamination of groundwater, particularly shallow groundwater sources and precipitation catchments associated with the long range transport of airborne pollutants. The information provided in this report on use of shallow groundwater wells and precipitation catchments to supply drinking water can be correlated with national and regional data concerning demography, climatology, geology and soils to identify those locations and populations potentially at greatest risk from geochemical changes to groundwater from acid rain. Quantifying the risk will require further investigation of representative sample areas. Selection of representative sample areas and the design of groundwater surveys to investigate the effect of acid rain on shallow groundwater will require specialist attention. However, in general terms examination of regional characteristics suggests that certain areas of southern Nova Scotia, southwestern New Brunswick, the north shore of the St. Lawrence in Quebec and shield areas of eastern Ontario are most likely to be at risk. Within each of these areas there is significant use of shallow wells and the natural geology and soils are by nature most likely to develop geochemical reactions, which could lead to contamination through leaching of metallic constituents. It is suggested that for each specific sample area selected, a survey should be conducted to establish the extent of the aquifer(s) involved, and a program of groundwater sampling and testing be designed to measure and monitor water quality changes over time. Such a monitoring program would require careful installation of control wells to ensure that trace indicators are not inadvertently introduced or that other surface contaminants would not obscure the geochemical indicators. Together with surveys to establish the extent of groundwater use and aquifer quality in the sample area, such monitoring surveys would provide the basic information necessary to quantify the nature of the risk. Correlating specific groundwater research from representative sample areas within regions identified as potentially at risk from acid rain should allow for regional characterization of risk levels and identification of measures required to protect the health of the populations.

The estimates developed from this study suggest there are in the order of 1 600 000 individual shallow wells in current use for domestic water supply. There are reported to be just under 1 000 000 well records on file with provincial authorities but these records include a unknown number of inactive wells which have been abandoned. Hence, the data base, while representative, may include only 50-60% of current active wells. The information available from the well records varies from jurisdiction to jurisdiction and, unfortunately, contains only limited information pertaining to water quality. Insofar as precipitation catchment systems throughout Canada are concerned, the estimates are even harder to make, since few governments have even shown concern for this source except for the dugout programs of PFRA in the prairie provinces. Recording of wells has been established within each provincial jurisdiction to monitor and regulate the use of groundwater and to adjudicate between conflicts in use. The data banks when first established did not perceive a need for monitoring groundwater quality. Drilling reports as illustrated in Annex 2, provide somewhat different levels of basic information by jurisdiction, as each established groundwater records to suit its own requirements. While many of the recording systems have been computerized, the systems are not compatible and those computerized systems which do exist, with a few exceptions,

do not allow for direct access. This is understandable, insofar as conflicts between adjacent wells is essentially a local problem for which a manual search of records represents a modest task.

It is only when broader regional characterization is required that the desirability for compatible computerization of well characteristics becomes apparent. Some regional characterization of groundwater sources and quality will be necessary to assess the risk of groundwater contamination from airborne pollutants. Other regional issues concerning groundwater use are likely to arise as increasing levels of withdrawal occur. For these reasons, it appears desirable for the Government of Canada, through Health and Welfare and other concerned federal departments, to provide some leadership to encourage and assist provincial authorities in revising or establishing compatible groundwater recording systems and protocols. The compatibility of provincial data would allow for the selection of well-characterized study areas for the conduct of research of national or interprovincial concern, e.g. the effect of long range transport of air pollutants on the quality of groundwater supplies.

Table 4.1
Estimated Use of Groundwater for Domestic Supply in Canada

	Total No. of Wells	Population Served	Shallow Wells (Less than 15 m Depth)	Population Served by Shallow Wells
Municipal Systems	4 070	3 616 000	1 050	453 000
Individual Systems	1 880 000	3 328 000	640 000	1 553 000
Total		6 944 000		2 006 000

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Annex 1

1986 Population Breakdown by Province/Territory

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Note: Census divisions throughout Canada are shown on Map 7 in Annex 6.

Table 1
Newfoundland: 1986 Population Breakdown

Census Division	Division Name	Population			
		Urban	Rural	Total	Rural as % of Total
01	Division No. 1	174 529	71 620	246 149	29.1
02	Division No. 2	17 120	13 165	30 285	43.5
03	Division No. 3	14 491	11 246	25 737	43.7
04	Division No. 4	11 726	15 552	27 278	57.0
05	Division No. 5	30 317	15 331	45 648	33.6
06	Division No. 6	34 926	5 788	40 714	14.2
07	Division No. 7	16 305	27 313	43 618	62.6
08	Division No. 8	15 578	38 647	54 225	71.3
09	Division No. 9	3 177	22 777	25 954	87.8
10	Division No. 10	16 563	12 178	28 741	42.4
Total		334 732	233 617	568 349	41.1

Source: Statistics Canada: Special Request by DGB Enviroconsultants

Table 2
Prince Edward Island: 1986 Population Breakdown

Census Division	Division Name	Population			
		Urban	Rural	Total	Rural as % of Total
01	King's County	3 373	16 136	19 509	82.7
02	Queen's County	30 945	32 515	63 460	51.2
03	Prince County	13 971	29 706	43 677	68.0
Total		48 289	78 357	126 646	61.9

Source: Statistics Canada: Special Request by DGB Enviroconsultants

Table 3
Nova Scotia: 1986 Population Breakdown

Census Division	Division Name	Population			
		Urban	Rural	Total	Rural as % of Total
01	Shelburne County	3 410	14 106	17 516	80.5
02	Yarmouth County	7 617	19 456	27 073	71.9
03	Digby County	2 525	19 327	21 852	88.4
04	Queens County	6 037	7 088	13 125	54.0
05	Annapolis County	2 890	20 699	23 589	87.8
06	Lunenburg County	12 951	33 532	46 483	72.1
07	Kings County	22 174	31 101	53 275	58.4
08	Hants County	5 022	31 526	36 548	86.3
09	Halifax County	239 174	67 244	306 418	22.0
10	Colchester County	20 061	25 032	45 093	55.5
11	Cumberland County	17 488	17 331	34 819	49.8
12	Pictou County	27 048	22 724	49 772	45.7
13	Guysborough County	2 336	10 385	12 721	81.6
14	Antigonish County	5 291	13 485	18 776	71.8
15	Inverness County	5 598	16 348	21 946	74.5
16	Richmond County	0	11 841	11 841	100.0
17	Cape Breton County	91 505	32 120	123 625	26.0
18	Victoria County	0	8 704	8 704	100.0
Total		471 127	402 049	873 176	46.0

Source: Statistics Canada: Special Request by DGB Enviroconsultants

Table 4
New Brunswick: 1986 Population Breakdown

Census Division	Division Name	Population			
		Urban	Rural	Total	Rural as % of Total
01	Saint John County	69 853	12 607	82 460	15.3
02	Charlotte County	6 644	19 881	26 525	75.0
03	Sunbury County	9 794	13 100	22 894	57.2
04	Queens County	4 215	8 272	12 487	66.2
05	Kings County	26 915	29 683	56 598	52.5
06	Albert County	15 638	9 194	24 832	37.0
07	Westmorland County	73 426	37 543	110 969	33.8
08	Kent County	4 167	27 329	31 496	86.8
09	Northumberland County	14 118	38 863	52 981	73.4
10	York County	46 042	31 169	77 211	40.4
11	Carleton County	4 549	20 880	25 429	82.1
12	Victoria County	8 654	12 850	21 504	59.8
13	Madawaska County	18 487	18 175	36 662	49.6
14	Restigouche County	19 537	20 384	39 921	51.1
15	Gloucester County	28 264	59 209	87 473	67.7
Total		350 303	359 139	709 442	50.6

Source: Statistics Canada: Special Request by DGB Enviroconsultants

Table 5
Quebec: 1986 Population Breakdown

Census Division	Division Name	Population			
		Urban	Rural	Total	Rural as % of Total
01	Îles-de-la-Madeleine	1 571	12 961	14 532	89.2
02	Gaspé-Est	10 650	30 212	40 862	73.9
03	Gaspé-Ouest	9 708	7 532	17 240	43.7
04	Bonaventure	11 670	27 906	39 576	70.5
05	Matapédia	9 501	13 975	23 476	59.5
06	Matane	15 324	13 934	29 258	47.6
07	Rimouski	40 179	29 766	69 945	42.6
08	Rivière-du-Loup	19 954	20 692	40 646	50.9
09	Témiscouata	7 487	11 784	19 271	61.2
10	Kamouraska	9 300	19 183	28 483	67.4
11	Charlevoix-Est	8 200	9 373	17 573	53.3
12	Charlevoix-Ouest	4 875	9 326	14 201	65.7
13	L'Islet	2 870	18 319	21 189	86.5
14	Montmagny	9 749	15 045	24 794	60.7
15	Bellechasse	3 830	19 407	23 237	83.5
16	Montmorency 2	0	6 769	6 769	100.0
17	Montmorency 1	11 988	10 963	22 951	47.8
20	Québec	456 015	10 468	466 483	2.2
21	Lévis	75 895	27 423	103 318	26.5
22	Dorchester	9 640	24 158	33 798	71.5
23	Beauce	40 890	35 092	75 982	46.2
24	Frontenac	7 934	18 456	26 390	69.9
25	Compton	6 177	13 933	20 110	69.3
26	Wolfe	4 208	11 015	15 223	72.4
27	Mégantic	36 630	18 398	55 028	33.4
28	Lotbinière	5 048	24 761	29 809	83.1
29	Portneuf	25 936	34 674	60 610	57.2
32	Champlain	77 710	41 853	119 563	35.0
33	Nicolet	7 260	26 902	34 162	78.8
34	Arthabaska	36 726	23 871	60 597	39.4
35	Richmond	20 644	18 009	38 653	46.6
36	Sherbrooke	102 903	17 648	120 551	14.6
37	Stanstead	24 675	14 071	38 746	36.3
38	Brome	2 757	15 290	18 047	84.7

Table 5
Quebec: 1986 Population Breakdown (Cont'd)

Census Division	Division Name	Population			
		Urban	Rural	Total	Rural as % of Total
39	Shefford	48 095	25 788	73 883	34.9
40	Bagot	9 297	18 869	28 166	67.0
41	Drummond	46 435	25 616	72 051	35.6
42	Yamaska	1 146	13 576	14 722	92.2
43	Saint-Maurice	95 537	13 496	109 033	12.4
47	Maskinongé	7 575	13 302	20 877	63.7
49	Berthier	13 482	18 562	32 044	57.9
50	Richelieu	40 054	11 783	51 837	22.7
51	Saint-Hyacinthe	41 550	15 477	57 027	27.1
52	Rouville	23 189	20 670	43 859	47.1
53	Iberville	8 547	15 384	23 931	64.3
54	Missisquoi	20 386	14 642	35 028	41.8
55	Saint-Jean	44 417	13 200	57 617	22.9
56	Chambly	312 374	3 963	316 337	1.3
57	Verchères	55 822	11 788	67 610	17.4
58	Joliette	32 823	30 520	63 343	48.2
61	Montcalm	8 784	20 468	29 252	70.0
62	L'Assomption	94 350	28 159	122 509	23.0
63	Terrebonne	153 631	53 026	206 657	25.7
64	Île-Jésus	284 164	0	284 164	0.0
65	Île-de-Montréal	1 752 582	0	1 752 582	0.0
66	Laprairie	99 372	11 245	110 617	10.2
67	Napierville	6 012	7 824	13 836	56.6
68	Huntingdon	2 919	12 708	15 627	81.3
69	Châteauguay	51 289	10 319	61 608	16.8
70	Beauharnois	46 312	6 794	53 106	12.8
71	Soulanges	2 590	13 755	16 345	84.2
72	Vaudreuil	36 413	17 008	53 421	31.8
73	Deux-Montagnes	55 792	20 088	75 880	26.5
74	Argenteuil	15 613	16 920	32 533	52.0
75	Papineau	17 811	22 447	40 258	55.8
76	Labelle	11 249	23 330	34 579	67.5
77	Gatineau	29 708	27 505	57 213	48.1
79	Hull	133 367	6 599	139 966	4.7

Table 5
Quebec: 1986 Population Breakdown (Cont'd)

Census Division	Division Name	Population			
		Urban	Rural	Total	Rural as % of Total
80	Pontiac	3 898	15 911	19 809	80.3
83	Témiscamingue	29 485	23 753	53 238	44.6
84	Abitibi	47 727	46 683	94 410	49.5
90	Lac-Saint-Jean-Ouest	31 517	31 460	62 977	50.0
93	Lac-Saint-Jean-Est	35 529	11 968	47 497	25.2
94	Chicoutimi	132 323	42 302	174 625	24.2
97	Saguenay	69 249	34 882	104 131	33.5
98	Territoire du Nouveau-Québec	18 676	18 507	37 183	49.8
Total		5 088 995	1 443 466	6 532 461	22.1

Source: Statistics Canada: Special Request by DGB Enviroconsultants

Table 6
Ontario: 1986 Population Breakdown

Census Division	Division Name	Population			
		Urban	Rural	Total	Rural as % of Total
01	Stormont, Dundas and Glengarry United Counties	58 258	44 004	102 262	43.0
02	Prescott and Russell United Counties	24 612	33 008	57 620	57.3
06	Ottawa-Carleton Regional Municipality	552 117	54 522	606 639	9.0
07	Leeds and Grenville United Counties	35 902	48 680	84 582	57.6
09	Lanark County	25 478	24 171	49 649	48.7
10	Frontenac	83 373	31 848	115 221	27.6
11	Lennox & Addington	11 198	23 156	34 354	67.4
12	Hastings County	72 056	37 296	109 352	34.1
13	Prince Edward County	5 440	16 987	22 427	75.7
14	Northumberland County	32 416	35 288	67 704	52.1
15	Peterborough County	68 704	36 352	105 056	34.6
16	Victoria	18 037	34 562	52 599	65.7
18	Durham Regional Municipality	265 180	60 999	326 179	18.7
19	York Regional Municipality	300 787	49 815	350 602	14.2
20	Toronto Metropolitan	2 192 721	0	2 192 721	0.0
21	Peel Regional Municipality	515 833	76 336	592 169	12.9
22	Dufferin County	18 599	14 036	32 635	43.0
23	Wellington County	100 497	38 939	139 436	27.9
24	Halton Regional Municipality	241 122	30 267	271 389	11.2
25	Hamilton-Wentworth Regional Municipality	385 898	37 500	423 398	8.9
26	Niagara Regional Municipality	323 857	46 275	370 132	12.5
28	Haldimand-Norfolk Regional Municipality	38 323	51 798	90 121	57.5
29	Brant County	85 227	21 040	106 267	19.8
30	Waterloo Regional Municipality	301 956	27 448	329 404	8.3
31	Perth County	41 176	25 432	66 608	38.2
32	Oxford County	51 605	33 759	85 364	39.6
34	Elgin County	39 499	30 836	70 335	43.8

Table 6
Ontario: 1986 Population Breakdown (Cont'd)

Census Division	Division Name	Urban	Rural	Total	Population Rural as % of Total
36	Kent County	69 131	37 601	106 732	35.2
37	Essex County	255 234	61 128	316 362	19.3
38	Lambton County	90 174	34 418	124 592	27.6
39	Middlesex County	290 911	41 560	332 471	12.5
40	Huron County	19 345	36 651	55 996	65.5
41	Bruce County	26 495	32 353	58 848	55.0
42	Grey County	37 067	37 692	74 759	50.4
43	Simcoe County	151 211	87 197	238 408	36.6
44	Muskoka District Municipality	17 019	23 216	40 235	57.7
46	Haliburton County	0	11 961	11 961	100.0
47	Renfrew County	48 339	40 626	88 965	45.7
48	Nipissing County	57 864	21 140	79 004	26.8
49	Parry Sound District	9 435	24 393	33 828	72.1
51	Manitoulin District	1 463	8 360	9 823	85.1
52	Sudbury District	9 415	16 356	25 771	63.5
53	Sudbury Regional Municipality	138 231	14 245	152 476	9.3
54	Timiskaming District	26 475	13 832	40 307	34.3
56	Cochrane District	64 607	29 105	93 712	31.1
57	Algoma District	98 687	33 154	131 841	25.2
58	Thunder Bay District	128 337	27 336	155 673	17.6
59	Rainy River District	13 986	8 885	22 871	38.9
60	Kenora District	26 123	26 711	52 834	50.6
Total		7 469 420	1 632 274	9 101 694	17.9

Source: Statistics Canada: Special Request by DGB Enviroconsultants

Table 7
Manitoba: 1986 Population Breakdown

Census Division	Division Name	Population			
		Urban	Rural	Total	Rural as % of Total
01	Division No. 1	3 091	13 171	16 262	81.0
02	Division No. 2	10 327	30 041	40 368	74.4
03	Division No. 3	18 001	20 421	38 422	53.2
04	Division No. 4	0	11 469	11 469	100.0
05	Division No. 5	6 263	10 232	16 495	62.0
06	Division No. 6	3 054	8 122	11 176	72.7
07	Division No. 7	44 951	12 161	57 112	21.3
08	Division No. 8	0	13 226	13 226	100.0
09	Division No. 9	13 198	10 038	23 236	43.2
10	Division No. 10	0	7 334	7 334	100.0
11	Division No. 11	591 128	3 423	594 551	0.6
12	Division No. 12	2 535	13 324	15 859	84.0
13	Division No. 13	11 861	21 758	33 619	64.7
14	Division No. 14	3 861	10 852	14 713	73.8
15	Division No. 15	5 434	18 384	23 818	77.2
16	Division No. 16	3 582	6 995	10 577	66.1
17	Division No. 17	10 846	15 676	26 522	59.1
18	Division No. 18	1 681	20 324	22 005	92.4
19	Division No. 19	0	9 125	9 125	100.0
20	Division No. 20	3 946	8 310	12 256	67.8
21	Division No. 21	15 531	8 537	24 068	35.5
22	Division No. 22	14 701	15 843	30 544	51.9
23	Division No. 23	2 869	7 390	10 259	72.0
Total		766 851	296 165	1 063 016	27.9

Source: Statistics Canada: Special Request by DGB Enviroconsultants

Table 8
Saskatchewan: 1986 Population Breakdown

Census Division	Division Name	Population			
		Urban	Rural	Total	Rural as % of Total
01	Division No. 1	13 652	20 161	33 813	59.6
02	Division No. 2	11 113	15 378	26 491	58.1
03	Division No. 3	5 312	14 080	19 392	72.6
04	Division No. 4	4 605	9 453	14 058	67.2
05	Division No. 5	15 548	24 767	40 315	61.4
06	Division No. 6	181 621	32 179	213 800	15.1
07	Division No. 7	37 235	16 471	53 706	30.7
08	Division No. 8	19 343	16 380	35 723	45.9
09	Division No. 9	22 013	21 442	43 455	49.3
10	Division No. 10	5 216	19 271	24 487	78.7
11	Division No. 11	191 152	26 079	217 231	12.0
12	Division No. 12	8 869	16 998	25 867	65.7
13	Division No. 13	10 197	18 459	28 656	64.4
14	Division No. 14	18 159	28 773	46 932	61.3
15	Division No. 15	41 442	40 816	82 258	49.6
16	Division No. 16	16 114	24 200	40 314	60.0
17	Division No. 17	11 131	26 644	37 775	70.5
18	Division No. 18	7 476	17 864	25 340	70.5
Total		620 198	389 415	1 009 613	38.6

Source: Statistics Canada: Special Request by DGB Enviroconsultants

Table 9
Alberta: 1986 Population Breakdown

Census Division	Division Name	Population			
		Urban	Rural	Total	Rural as % of Total
01	Division No. 1	47 031	9 561	56 592	16.9
02	Division No. 2	84 852	30 887	115 739	26.7
03	Division No. 3	16 691	18 279	34 970	52.3
04	Division No. 4	3 017	9 359	12 376	75.6
05	Division No. 5	13 846	24 959	38 805	64.3
06	Division No. 6	676 546	39 059	715 605	5.5
07	Division No. 7	13 877	26 804	40 681	65.9
08	Division No. 8	80 504	36 107	116 611	31.0
09	Division No. 9	5 182	10 817	15 999	67.6
10	Division No. 10	36 543	43 202	79 745	54.2
11	Division No. 11	722 525	84 979	807 504	10.5
12	Division No. 12	22 862	21 045	43 907	47.9
13	Division No. 13	17 360	37 613	54 973	68.4
14	Division No. 14	15 952	9 357	25 309	37.0
15	Division No. 15	16 417	6 377	22 794	28.0
16	Division No. 16	37 502	11 277	48 779	23.1
17	Division No. 17	14 797	34 055	48 852	69.7
18	Division No. 18	7 645	5 942	13 587	43.7
19	Division No. 19	44 609	28 388	72 997	38.9
Total		1 877 758	488 067	2 365 825	20.6

Source: Statistics Canada: Special Request by DGB Enviroconsultants

Table 10
British Columbia: 1986 Population Breakdown

Census Division	Division Name	Population			
		Urban	Rural	Total	Rural as % of Total
01	East Kootenay Regional District	34 056	19 033	53 089	35.9
03	Central Kootenay Regional District	21 876	27 234	49 110	55.5
05	Kootenay Boundary Regional District	19 706	10 629	30 335	35.0
07	Okanagan-Similkameen Regional District	35 060	24 029	59 089	40.7
09	Fraser-Cheam Regional District	36 908	21 057	57 965	36.3
11	Central Fraser Valley Regional District	92 956	43 936	136 892	32.1
13	Dewdney-Alouette Regional District	45 390	24 104	69 494	34.7
15	Greater Vancouver Regional District	1 244 491	21 661	1 266 152	1.7
17	Capital Regional District	236 361	28 253	264 614	10.7
19	Cowichan Valley Regional District	19 751	32 715	52 466	62.4
21	Nanaimo Regional District	58 522	23 658	82 180	28.8
23	Alberni-Clayoquot Regional District	21 893	8 448	30 341	27.8
25	Comox-Strathcona Regional District	43 751	27 394	71 145	38.5
27	Powell River Regional District	12 440	5 934	18 374	32.3
29	Sunshine Coast Regional District	3 899	12 859	16 758	76.7
31	Squamish-Lillooet Regional District	6 876	11 015	17 891	61.6
33	Thompson-Nicola Regional District	66 152	30 653	96 805	31.7
35	Central Okanagan Regional District	58 702	31 028	89 730	34.6
37	North Okanagan Regional District	27 147	27 673	54 820	50.5
39	Columbia-Shuswap Regional District	18 026	21 891	39 917	54.8

Table 10
British Columbia: 1986 Population Breakdown

Census Division	Division Name	Population			
		Urban	Rural	Total	Rural as % of Total
41	Cariboo Regional District	24 437	35 058	59 495	58.9
43	Mount Waddington Regional District	6 699	8 235	14 934	55.1
45	Central Coast Regional District	0	3 120	3 120	100.0
47	Skeena-Queen Charlotte Regional District	14 170	8 891	23 061	38.6
49	Kitimat-Stikine Regional District	25 485	13 998	39 483	35.5
51	Bulkley-Nechako Regional District	15 569	21 901	37 470	58.5
53	Fraser-Fort George Regional District	64 981	24 356	89 337	27.3
55	Peace River-Liard Regional District	29 700	27 578	57 278	48.2
57	Stikine Region	0	2 022	2 022	100.0
Total		2 285 004	598 363	2 883 367	20.8

Source: Statistics Canada: Special Request by DGB Enviroconsultants

Table 11
Yukon: 1986 Population Breakdown

Census Division	Division Name	Urban	Rural	Total	Population Rural as % of Total
01	Yukon	15 199	8 305	23 504	35.3
Total		15 199	8 305	23 504	35.3

Source: Statistics Canada: Special Request by DGB Enviroconsultants

Table 12
Northwest Territories: 1986 Population Breakdown

Census Division	Division Name	Urban	Rural	Total	Population Rural as % of Total
04	Baffin Region	2 938	7 037	9 975	70.6
05	Keewatin Region	0	4 986	4 986	100.0
06	Forth Smith Region	17 882	7 234	25 116	28.8
07	Inuvik Region	3 389	5 022	8 411	59.7
08	Kitikmeot Region	0	3 750	3 750	100.0
Total		24 209	28 029	52 238	53.7

Source: Statistics Canada: Special Request by DGB Enviroconsultants

Annex 2

Format of Well Records Required from Water Well Drillers

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Newfoundland	55
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Northwest Territories	na

FORM C
DEPARTMENT OF ENVIRONMENT
PROVINCE OF NEWFOUNDLAND

WATER WELL RECORD

Print or Type

OWNER OF WELL

Name	Address	Date Completed
		Day _____ Mo. _____ Yr. _____

LOCATION OF WELL

District	Town
Index Map. No.	Co-ordinates

SKETCH

Show 2 Distances from Nearest Roads or Landmarks and Indicate North by Arrow

DRILLER

Name (Signed)	
Address	
License No.	Submission Date Day _____ Mo. _____ Yr. _____

STRATIGRAPHIC LOG OF OVERBURDEN AND BEDROCK

Depth - metre From	Depth - metre To	General Color	Most Common Material	Other Materials	General Description

TYPE OF WELL

Method of Drilling
- ☐ Cable Tool
- ☐ Rotary (Conventional)
- ☐ Rotary (Reverse)
- ☐ Rotary Air
- ☐ Air
- ☐ Boring
- ☐ Diamond
- ☐ Jetting
- ☐ Driving

Casing-Open Hole: Inside Dia. mm	Material	Depth - metre From	Depth - metre To
	Casing / Open Hole		
	Casing / Open Hole		
	Casing / Open Hole		

Screen

Size(s) of Opening (Slot No.)	Slotted Casing
Diameter mm	Length metre
Material and Type	Depth to top of Screen metre

Total Depth Below Surface metre	Casing Setting: Cemented ☐ Driven ☐ Loose ☐ Packer ☐	Diameter at Lowest Level mm

WATER OCCURRENCE

Water Found at - metre	Kind of Water	
	☐ Fresh ☐ Salty	☐ Sulfur ☐ Mineral
	☐ Fresh ☐ Salty	☐ Sulfur ☐ Mineral
	☐ Fresh ☐ Salty	☐ Sulfur ☐ Mineral
	☐ Fresh ☐ Salty	☐ Sulfur ☐ Mineral

Well Development
Surged ☐ Acidized ☐ Flushed ☐ Other ☐

PUMPING TEST

Pumping Test Method ☐ Pump ☐ Bailer	Pumping Rate ..... L/min	Duration of Pumping ..... h ..... min
Static Water Level metre	Drawdown metre	If Flowing Give Rate ..... L/min
Water Levels During Pumping metre: 15 min ..... 30 min ..... 45 min ..... 60 min		
Water Levels During Recovery metre: 15 min ..... 30 min ..... 45 min ..... 60 min		
Water Level at End of Pumping metre	Water at End of Test ☐ Clear ☐ Cloudy	Pump Intake Set at metre
Recommended Pump Type ☐ Shallow ☐ Deep	Recommended Pump Setting ..... metre	Recommended Pumping Rate ..... L/min

QUALITY OF WATER

Color	Odor	Turbidity	Hardness	Chemicals Above Canadian Standards	Sample Taken
☐ None ☐ Red ☐ Brown ☐ Other	☐ None ☐ Gas ☐ Sulfur ☐ Other	☐ Clear ☐ Silty ☐ Sandy ☐ Cloudy	☐ Soft ☐ Medium ☐ Hard	☐ Iron ☐ Manganese ☐ Other	☐ Yes ☐ No Attach Results of Analysis

FINAL STATUS OF WELL

- ☐ Water Supply
- ☐ Observation Hole
- ☐ Test Hole
- ☐ Abandoned - Insufficient Supply
- ☐ Abandoned - Poor Quality
- ☐ Unfinished

WATER USE

- ☐ Domestic
- ☐ Public Supply
- ☐ Municipal
- ☐ Industrial
- ☐ Commercial
- ☐ Other

SHEET 1 WHITE - DEPARTMENT COPY; SHEET 2 PINK - DRILLERS' COPY; SHEET 3 BLUE - OWNER'S COPY

WATER WELL DRILLER'S REPORT
Prince Edward Island

Office Use Only: Map ..... Q .....

GOWN NO. .....

Well ..... Test Hole ..... Observation Hole .....

OWNER OF WELL

Name .....

Address .....

Building Permit No. .....

LOCATION OF WELL

County .....

Locality .....

Reference Map .....

UTM Coordinates: Easting ..... Northing .....

Ground Elevation ..... ft.

WELL DATA

Drilling method ..... cable tool ..... rotary ..... dug

Total depth below ground surface ..... ft.

Diameter: ..... in. from ..... ft. to ..... ft.

..... in. from ..... ft. to ..... ft.

Casing: ..... in. from ..... ft. to ..... ft.

..... in. from ..... ft. to ..... ft.

How Set: ..... driven ..... cemented

Well Finish: ..... open hole ..... screen

..... slotted casing

Well Development: ..... bailed ..... surged

..... flushed ..... pumped

WATER OCCURRENCES

Water: 1. at ..... ft. to ..... ft.

type: fresh ..... salty ..... other .....

2. at ..... ft. to ..... ft.

type: fresh ..... salty ..... other .....

3. at ..... ft. to. ..... ft.

type: fresh ..... salty ..... other .....

4. at ..... ft. to ..... ft.

type: fresh ..... salty ..... other .....

Static water level after well completed ..... ft.

PUMP OR BAILER TEST

Bailed or pumped at ..... IGPM for ..... hr. ..... min.

Drawdown ..... ft. ..... in. in ..... hr. ..... min.

Recovered to ..... ft. ..... in. in ..... hr. ..... min.

WATER QUALITY

Was water satisfactory? ..... Yes ..... No

If "NO" state why .....

Sample taken for analysis ..... Yes ..... No

Use: ..... domestic ..... municipal ..... industrial

1. Original to P.E.I. Department of the Environment
2. Duplicate to client
3. Remain in book

DRILLER

Driller's Name .....

Company Name .....

Address .....

License No. ..... Year .....

Date of Completion of Well

.....day.....month.....Year

SKETCH OF WELL LOCATION

STRATIGRAPHIC LOG		
FROM FT.	TO FT.	DESCRIPTION

Depth to top of bedrock ..... ft.

Driller's comments: .....

.....

.....

.....

.....

DUG WELL REPORT

P. O. Box 2107, Halifax, N. S.
Nova Scotia Dept. of Environment
B3J 2X1

1 Original to:
Dept. of Environment

A. OWNER OF WELL:

Name: .....

Address: .....

Location of Well: .....

County: .....

Municipality ..... Date: .....

Nova Scotia Mining Grid Map Location:

.....

WELL CONTRACTOR:

Name (signed) .....

Address .....

License No. ..... Year .....

Well Completed: Day ..... Month .....

B. TYPE OF WELL

Proper Distance from Disposal System: Yes ..... No: .....

Total Depth: ..... Diameter: .....

Gravel Used Yds. .....

Rocked-up to: ..... ft. .....

Type of Casing or Liner Used: .....

Crocks ..... Cement ..... Earthen ..... Other .....

Length of Liners or Casing used ..... ft. .....

Material Used to Backfill to Surface of Excavation:

Clay ..... Cement Grout ..... Slurry ..... Other .....

Concrete Apron below Surface:

Ft. Below Surface: Width ..... Thickness .....

Crock joints cemented: Yes ..... No .....

C. WATER OCCURRENCE AND TESTS:

Water at ..... ft. to ..... ft. below surface.

Estimated output in gallons per minute:

Bailed or Pumped at ..... gpm. for ..... mins. hrs.

Drawdown ..... ft. in ..... mins. hrs.

Recovered to ..... ft. in ..... mins. hrs.

D. WATER QUALITY:

Colour: None ..... Red ..... Brown ..... Other .....

Odor: None ..... Gas ..... Sulphur ..... Other .....

Turbidity: Clear ..... Silty ..... Sandy ..... Cloudy .....

Type: Soft ..... Medium Hard ..... Hard .....

Use: Domestic ..... Industrial ..... Other .....

Was water supply satisfactory? Yes ..... No .....

If no, give reason:

Analysis carried out: Chemical ..... Bacterial .....

Was Log copy given to customer? Yes ..... No

STRATIGRAPHIC LOG

FROM FT.	TO FT.	DESCRIPTION

Well bottomed in:

Gravel .....

Sand .....

Rock ..... Type .....

Depth to top of bedrock ..... ft.

Nova Scotia Department of the Environment

DRILLED WELL REPORT

N.S.D.O.E. WELL #

FOR DEPARTMENTAL USE ONLY

WELL DRILLING CONTRACTOR	WELL OWNER	CONTRACTOR
NAME:	NAME:	NAME:
	ADDRESS:	ADDRESS:
LICENSE NUMBER		
DATE WELL COMPLETED	POSTAL CODE	POSTAL CODE

STRATIGRAPHIC LOG

DEPTH IN FEET		COLOR	GENERAL DESCRIPTION OF OVERBURDEN AND/OR BEDROCK	WELL SKETCH
GROUND LEVEL	TO			

MAP REFERENCE

PAGE NUMBER _____

REFERENCE LETTER ____

REFERENCE NUMBER ____

E. _____

N. _____

DEPARTMENTAL USE

ROAMER LETTER ____

ROAMER NUMBER ____

LOCATION WITHIN ROAMER SQUARE

WELL LOCATION SKETCH

WELL INFORMATION

TOTAL DEPTH BELOW SURFACE _____ FT.

CASING ____ IN. TO _____ FT.; _____ IN. TO _____ FT.

CASING WALL THICKNESS _____ IN.

LENGTH OF CASING ABOVE GROUND _____ FT. ____ IN.

DRIVESHOE ☐ GROUT ☐ PACKER ☐

WELL FINISH: OPEN HOLE ☐ SLOTTED CASING ☐

SCREEN ☐ MAKE _____

SLOT SIZE _____ LENGTH _____ FT.

WATER BEARING FRACTURES ENCOUNTERED ____ FT.

_____ FT. _____ FT. _____ FT. _____ FT.

DRILLER'S COMMENTS: _____

PUMPING TEST

METHOD: AIR ☐ BAILER ☐ PUMP ☐

RATE: _____ G.P.M.

DURATION: _____ HOURS _____ MINS.

STATIC LEVEL	WATER LEVEL END OF TEST
_____ FT.	_____ FT.

TEST DEPTH _____ FT.

DRAW DOWN _____ FT.

WATER COLOR

WATER LEVEL RECOVERED TO _____ FEET BY _____ HR. _____ MIN. AFTER TEST

FINAL STATUS OF WELL

- ☐ WATER SUPPLY
- ☐ OBSERVATION WELL
- ☐ TEST HOLE
- ☐ RECHARGE WELL
- ☐ ABANDONED, INSUFFICIENT SUPPLY
- ☐ ABANDONED, POOR QUALITY
- ☐ ABANDONED, SALTWATER
- ☐ UNFINISHED

WATER USE

- ☐ DOMESTIC
- ☐ INDUSTRIAL
- ☐ COMMERCIAL
- ☐ MUNICIPAL
- ☐ OTHER _____
- ☐ IRRIGATION
- ☐ PUBLIC SUPPLY
- ☐ AGRICULTURAL
- ☐ HEAT PUMP

METHOD OF DRILLING

- ☐ CABLE TOOL
- ☐ ROTARY
- ☐ JET
- ☐ OTHER

DRILLING FLUIDS ☐ TYPE: _____

I CERTIFY THAT THE WELL HEREIN DESCRIBED HAS BEEN CONSTRUCTED IN ACCORDANCE WITH THE WELL DRILLING ACT OF NOVA SCOTIA.

SIGNATURE: _____ DATE: _____

MAIL TO:
NOVA SCOTIA DEPARTMENT OF THE ENVIRONMENT
P.O. BOX 2107
HALIFAX, N.S.
B3J 3B7

FORM DISTRIBUTION: WHITE — N.S.D.O.E., PINK — CUSTOMER, BLUE — DRILLER.

WATER WELL DRILLER'S REPORT
RAPPORT DU FOREUR DE PUITS D'EAU

55-1417 (10/86)

Department of Municipal Affairs and Environment
Water Resources Branch

Ministère des Affaires municipales et de l'Environnement
Direction des ressources de l'eau

Owner Propriétaire	
No. and Street No. et rue	
Town or County Ville ou comté	Phone
Atlas Page No. Atlas page	Ref. Map Carte de rél. / Co-ordinates Coordonnées / East Est / North Nord
☑ Drilling Method Méthode de forage	Churn A câble 1 ☐ / Dug Creusé 2 ☐ / Rotary-air Rotatif (air) 3 ☐ / Air Percussion Percussion à l'air 4 ☐
☑ Well development Développement du puits	Air Lift Remontée pneumatique 1 ☐ / Bailed Curage 2 ☐ / Other Autre 3 ☐ / Estimated Safe Yield Débit de sécurité gal. / min.
	Final level Niveau final ft. / pi. / in. / po. / Pumping rate Taux de pompage gal. / min. / Duration of pm Durée du pomp. hrs. / mins. / Spec. Capacity Capacité spéc.
Remarks Remarques	
☑ Water Use Usage de l'eau	Domestic Domestique 1 ☐ / Municipal Municipal 3 ☐ / Stock Bétail 5 ☐ Public Public 2 ☐ / Industrial Industrial 4 ☐ / Not Used Non-utilisation 6 ☐
☑ Final Status Etat final	Water Supply Approvisionnement 1 ☐ / Recharge Well Puits réalimentation 3 ☐ / Observation Observation 5 ☐ Abandoned Abandonné 2 ☐ / Test Hole Trou d'essai 4 ☐ / Unfinished Inachevé 6 ☐
Company Name Nom du compagnie	
License Number No. du permis	Completion Date Achèvement du puits D J M M Y A

I certify that the well herein described has been constructed in accordance with the Water Well Regulation of the Clean Environment Act.
J'atteste que le puits décrit ici a été construit en conformité du Règlement sur les puits d'eau de la Loi sur l'assainissement de l'environnement.

Signature

FOR OFFICE USE / A L'USAGE DU BUREAU

Date Received
Date reçu

C ☐ M ☐

DRILLER'S LOG
REGISTRE DU FOREUR DE PUITS D'EAU

At ft. / Niv. pi.	Color / Couleur	Description
0		

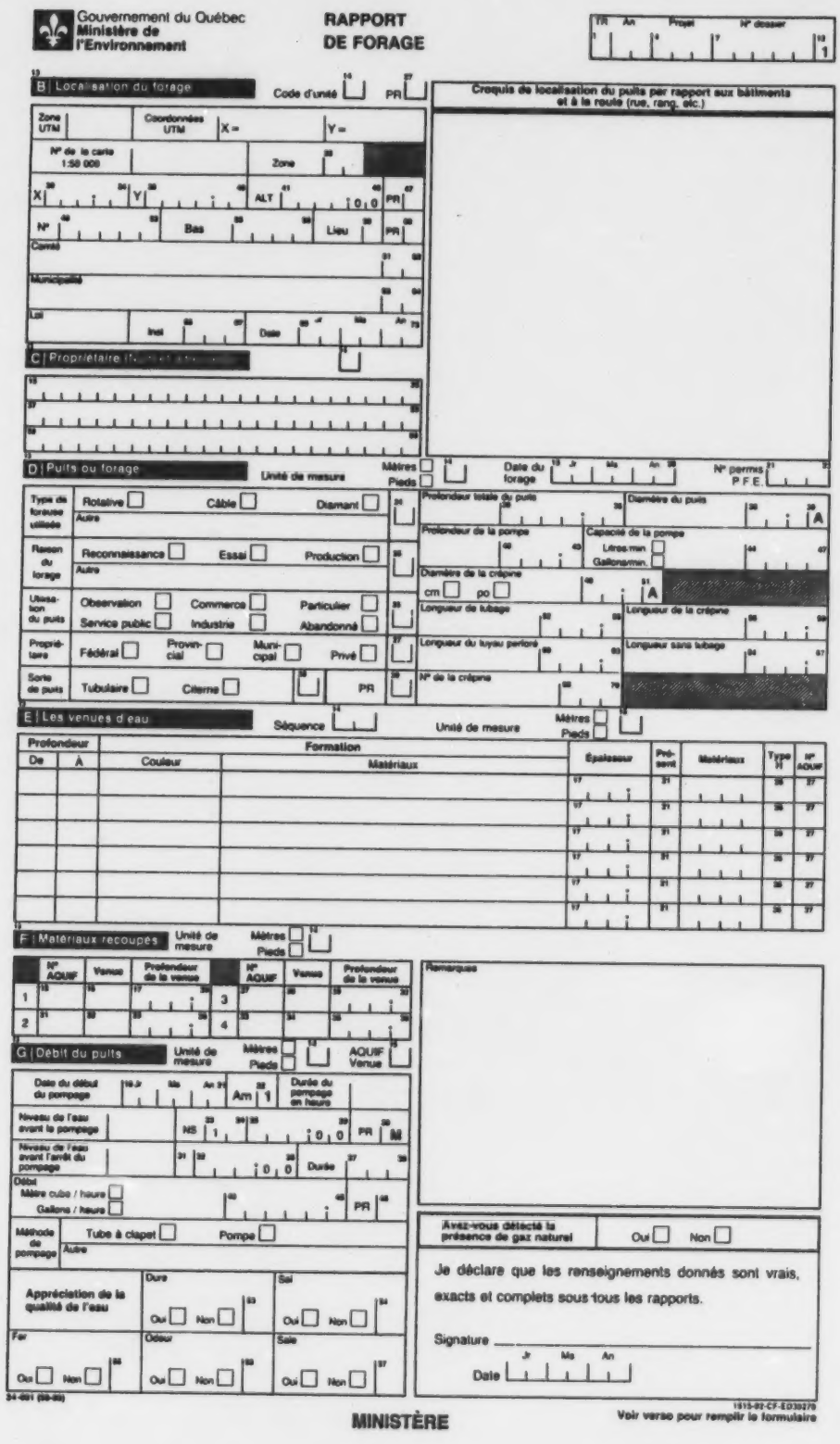
Total depth of hole Profondeur totale du trou	Depth to rock Profondeur au roc
Ft. / Pi.	Ft. / Pi.

WATER BEARING HORIZONS
NIVEAUX AQUIFERES

At ft. / Niv. pi.	Yield / Rendement	Type

CASING RECORD
REGISTRE DU TUBAGE

At ft. / Niv. pi.	Length Longeur	Diam	Type


Gouvernement du Québec
Ministère de l'Environnement

RAPPORT DE FORAGE

TR | An | Projet | N° dossier

B | Localisation du forage — Code d'unité | PR

Zone UTM | Coordonnées UTM X = | Y =

N° de la carte 1:50 000 | Zone

X | Y | ALT | PR

N° | Bas | Lieu | PR

Comté

Municipalité

Lot | Rang | Date

Croquis de localisation du puits par rapport aux bâtiments et à la route (rue, rang, etc.)

C | Propriétaire

D | Puits ou forage — Unité de mesure: Mètres / Pieds | Date du forage | N° permis P.F.E.

Type de foreuse utilisée: Rotative / Câble / Diamant / Autre

Raison du forage: Reconnaissance / Essai / Production / Autre

Utilisation du puits: Observation / Commerce / Particulier / Service public / Industrie / Abandonné

Propriétaire: Fédéral / Provincial / Municipal / Privé

Sorte de puits: Tubulaire / Citerne | PR

Profondeur totale du puits | Diamètre du puits

Profondeur de la pompe | Capacité de la pompe: Litres/mn / Gallons/mn

Diamètre de la crépine: cm / po

Longueur de tubage | Longueur de la crépine

Longueur du tuyau perforé | Longueur sans tubage

N° de la crépine

E | Les venues d'eau — Séquence | Unité de mesure: Mètres / Pieds

Profondeur De	Profondeur À	Formation Couleur	Formation Matériaux	Épaisseur	Présent	Matériaux	Type H	N° AQUIF

F | Matériaux recoupés — Unité de mesure: Mètres / Pieds

	N° AQUIF	Venue	Profondeur de la venue		N° AQUIF	Venue	Profondeur de la venue
1				3			
2				4			

Remarque

G | Débit du puits — Unité de mesure: Mètres / Pieds | AQUIF Venue

Date du début du pompage | Am | Durée du pompage en heure

Niveau de l'eau avant la pompage | NS | PR | M

Niveau de l'eau avant l'arrêt du pompage | Durée

Débit: Mètre cube / heure / Gallons / heure | PR

Méthode de pompage: Tube à clapet / Pompe / Autre

Appréciation de la qualité de l'eau

	Oui	Non
Dure		
Sel		
Fer		
Odeur		
Sale		

Avez-vous détecté la présence de gaz naturel? Oui / Non

Je déclare que les renseignements donnés sont vrais, exacts et complets sous tous les rapports.

Signature _____

Date

34-001 (89-06)

MINISTÈRE

1915-02-CF-ED30270

Voir verso pour remplir le formulaire

Ministry of the Environment
Ontario

The Ontario Water Resources Act

WATER WELL RECORD

1 PRINT ONLY IN SPACES PROVIDED
2 CHECK (✓) CORRECT BOX WHERE APPLICABLE

COUNTY OR DISTRICT | TOWNSHIP BOROUGH CITY TOWN VILLAGE | LOT | CON | SURVEY | BLOCK TRACT

OWNER (SURNAME FIRST) | ADDRESS | DATE COMPLETED DAY MO YR

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH FEET FROM	TO

WATER RECORD

WATER FOUND AT FEET	KIND OF WATER		
	☐ FRESH	☐ SULPHUR	☐ MINERALS
	☐ SALTY	☐ GAS	
	☐ FRESH	☐ SULPHUR	☐ MINERALS
	☐ SALTY	☐ GAS	
	☐ FRESH	☐ SULPHUR	☐ MINERALS
	☐ SALTY	☐ GAS	
	☐ FRESH	☐ SULPHUR	☐ MINERALS
	☐ SALTY	☐ GAS	
	☐ FRESH	☐ SULPHUR	☐ MINERALS
	☐ SALTY	☐ GAS	

CASING & OPEN HOLE RECORD

INSIDE DIAM (INCHES)	MATERIAL	WALL THICKNESS (INCHES)	DEPTH FEET FROM	TO
	☐ STEEL ☐ GALVANIZED ☐ CONCRETE ☐ OPEN HOLE ☐ PLASTIC			
	☐ STEEL ☐ GALVANIZED ☐ CONCRETE ☐ OPEN HOLE ☐ PLASTIC			
	☐ STEEL ☐ GALVANIZED ☐ CONCRETE ☐ OPEN HOLE ☐ PLASTIC			

SCREEN

SIZE OF OPENING (SLOT NO.) | DIAMETER (INCHES) | LENGTH (INCHES)

MATERIAL AND TYPE | DEPTH TO TOP OF SCREEN FEET

PLUGGING & SEALING RECORD

DEPTH SET AT FEET FROM	TO	MATERIAL AND TYPE (CEMENT GROUT, LEAD PACKER ETC.)

PUMPING TEST

PUMPING TEST METHOD ☐ PUMP ☐ BAILER | PUMPING RATE | DURATION OF PUMPING HOURS MIN

STATIC LEVEL | WATER LEVEL END OF PUMPING | WATER LEVELS DURING ☐ PUMPING ☐ RECOVERY

10 MINUTES	20 MINUTES	30 MINUTES	40 MINUTES	50 MINUTES	60 MINUTES
FEET	FEET	FEET	FEET	FEET	FEET

IF FLOWING GIVE RATE | PUMP INTAKE SET AT | WATER AT END OF TEST ☐ CLEAR ☐ CLOUDY

RECOMMENDED PUMP TYPE ☐ SHALLOW ☐ DEEP | RECOMMENDED PUMP DEPTH FEET | RECOMMENDED PUMPING RATE GPM

LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE. INDICATE NORTH BY ARROW

DRILLERS REMARKS

64211

FINAL STATUS OF WELL
☐ WATER SUPPLY ☐ ABANDONED INSUFFICIENT SUPPLY
☐ OBSERVATION WELL ☐ ABANDONED POOR QUALITY
☐ TEST HOLE ☐ UNFINISHED
☐ RECHARGE WELL ☐ DEWATERING

WATER USE
☐ DOMESTIC ☐ COMMERCIAL
☐ STOCK ☐ MUNICIPAL
☐ IRRIGATION ☐ PUBLIC SUPPLY
☐ INDUSTRIAL ☐ COOLING OR AIR CONDITIONING
☐ OTHER ☐ NOT USED

METHOD OF CONSTRUCTION
☐ CABLE TOOL ☐ BORING
☐ ROTARY (CONVENTIONAL) ☐ DIAMOND
☐ ROTARY (REVERSE) ☐ JETTING
☐ ROTARY (AIR) ☐ DRIVING
☐ AIR PERCUSSION ☐ DIGGING ☐ OTHER

CONTRACTOR

NAME OF WELL CONTRACTOR | WELL CONTRACTOR'S LICENCE NUMBER

ADDRESS

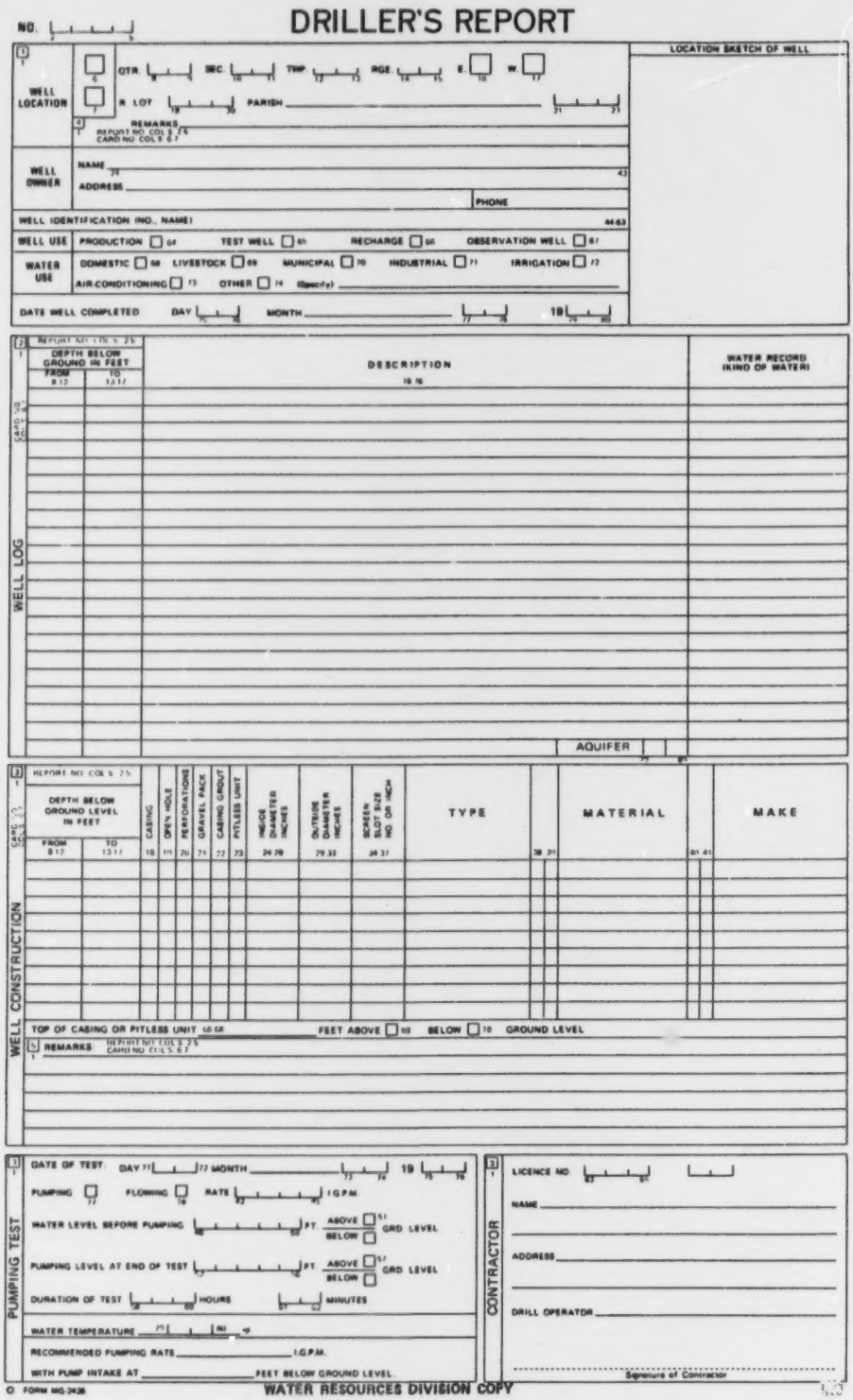
NAME OF WELL TECHNICIAN | WELL TECHNICIAN'S LICENCE NUMBER

SIGNATURE OF TECHNICIAN/CONTRACTOR | SUBMISSION DATE DAY MO YR

OFFICE USE ONLY

CONTRACTOR'S COPY

FORM NO 0506 (11) 80 FORM 9



NO.

DRILLER'S REPORT

LOCATION SKETCH OF WELL

WELL LOCATION — QTR. SEC. TWP. RGE. E. W. — R. LOT PARISH — REMARKS (REPORT NO. COLS 1-6, CARD NO. COL 6-7)

WELL OWNER — NAME — ADDRESS — PHONE

WELL IDENTIFICATION (NO., NAME)

WELL USE — PRODUCTION TEST WELL RECHARGE OBSERVATION WELL

WATER USE — DOMESTIC LIVESTOCK MUNICIPAL INDUSTRIAL IRRIGATION — AIR-CONDITIONING OTHER (Specify)

DATE WELL COMPLETED — DAY — MONTH — 19

WELL LOG

DEPTH BELOW GROUND IN FEET FROM	TO	DESCRIPTION	WATER RECORD (KIND OF WATER)

AQUIFER

WELL CONSTRUCTION

DEPTH BELOW GROUND LEVEL IN FEET FROM	TO	CASING	OPEN HOLE	PERFORATIONS	GRAVEL PACK	CASING GROUT	PITLESS UNIT	INSIDE DIAMETER INCHES	OUTSIDE DIAMETER INCHES	SCREEN SLOT SIZE NO. OR INCH	TYPE		MATERIAL		MAKE

TOP OF CASING OR PITLESS UNIT — FEET ABOVE BELOW GROUND LEVEL

REMARKS (REPORT NO. COLS 1-6, CARD NO. COLS 6-7)

PUMPING TEST

DATE OF TEST. DAY MONTH 19

PUMPING FLOWING RATE I.G.P.M.

WATER LEVEL BEFORE PUMPING FT. ABOVE BELOW GRD. LEVEL

PUMPING LEVEL AT END OF TEST FT. ABOVE BELOW GRD. LEVEL

DURATION OF TEST HOURS MINUTES

WATER TEMPERATURE

RECOMMENDED PUMPING RATE I.G.P.M.

WITH PUMP INTAKE AT FEET BELOW GROUND LEVEL

CONTRACTOR

LICENCE NO.

NAME

ADDRESS

DRILL OPERATOR

Signature of Contractor

FORM MG-3428

WATER RESOURCES DIVISION COPY

SASKATCHEWAN WATER CORPORATION

DRILLER'S REPORT FORM

Water Well Driller's Report

PLEASE PRINT

Owner's Name	Address	Drilling Contractor	Registration Number

Description of Well

Hole Number | Date Completed: Day / Month / Year

Method Installed (Please Check)
- ☐ 1. Drilled
- ☐ 2. Bored
- ☐ 3. Augered
- ☐ 4. Jetted
- ☐ 5. Hand Dug
- ☐ 6. Backhoe
- ☐ 7. Other
- ☐ 8. Unknown

Test Hole Depth (feet)

Bit Diameter (inches)

Depth Water Struck (feet)

Water Level Before Pumping (feet)

If Flowing Artesian, Head Above Ground (feet)

Completion Method (Please Check)
- ☐ 1. Well Screen
- ☐ 2. Well Screen and Gravel Pack
- ☐ 3. Sand Point
- ☐ 4. Perforated Casing (Slotted or Sawed)
- ☐ 5. Open Hole
- ☐ 6. Curbed
- ☐ 7. Spring
- ☐ 8. Other
- ☐ 9. Unknown

Location of Well in Quarter

Feet From ☐ N ☐ S Boundary

Feet From ☐ E ☐ W Boundary

Legal Description of Quarter

Quarter Section | Township | Range | West of Mer

Purpose of Water Use (Please Check)
- ☐ 1. Domestic
- ☐ 2. Municipal
- ☐ 3. Industrial
- ☐ 4. Irrigation
- ☐ 5. Recreation
- ☐ 6. Mineral Water
- ☐ 7. Mineral Recovery
- ☐ 8. Multi-Purpose
- ☐ 9. Research

Description of Well Casing

Length (feet)	Bottom Set At (feet)	Diameter (inches)	Code	Material Description

Description of Screens or Perforated Material

Material Description	Material Code	Slot Size (1/1000 inch)	Diameter (inches)	Length (feet)	Bottom Set At (feet)

Method of Coupling: [ ] Threaded. [ ] Telescoped. Other_____

Use of Well (Please Check)
- ☐ 1. Withdrawal
- ☐ 2. Observation
- ☐ 3. Quality Monitoring
- ☐ 4. Recharge
- ☐ 5. Waste Disposal
- ☐ 6. Water Test Hole
- ☐ 7. Seismic Test Hole
- ☐ 8. Mineral Test Hole
- ☐ 9. Soil Test Hole

Pump Test

Draw Down (feet) | Duration of Test (hours) | Pumping Rate (GPM)

Electric ☐ 1. Yes

Log ☐ 2. No

Recommended

Pumping Rate (GPM) | Pump Intake Set At (feet)

Water Temperature (°F)

Driller's Log

Description of Material Encountered	Depth To (feet)	Material Codes: Primary	Colour	Description

SWC 988 ●

Driller's Signature

Note: Shaded Areas Are For Corporation Use Only

Saskatchewan Water Corporation

N.T.S. Map Number	
Major Basin Number	
Sub-Basin Number	
Physiographical Division	
Elevation of Ground Surface (Feet)	
Specific Capacity (IGPM/Feet)	
Permeability (IGPD/Feet ^{2})	
Coefficient of Transmissivity (IGPD/Feet)	
Coefficient of Storage	

Producing Aquifer Please Check Below

- ☐ 01 Glacial
- ☐ 21 Cypress Hills
- ☐ 22 Ravenscrag
- ☐ 23 Eastend
- ☐ 24 Bearpaw
- ☐ 25 Belly River (Judith River, Oldman, Ribstone Creek)
- ☐ 27 Lea Park
- ☐ 28 Viking
- ☐ 29 Blairmore (Swan River)
- ☐ 30 Other Bedrock Formation
- ☐ 40 Undetermined

Chemical Analysis

Date of Analysis	Agency Who Did Analysis	

Acquisition Number		Quantity (PPM)
Total Hardness		
Calcium Hardness		
Iron	(Fe)	
Manganese	(Mn)	
Calcium	(Ca)	
Magnesium	(Mg)	
Sodium	(Na)	
Bicarbonate	(HCO_3)	
Carbonate	(CO_3)	
Chloride	(Cl)	
Sulphate	(SO_4)	
Nitrate	(NO_3)	
Fluoride	(F)	
Total Dissolved Solids (TDS)		
Total Alkalinity		
Conductivity Micromhos/cm		
pH		

Comments:

WATER WELL DRILLERS REPORT

Alberta ENVIRONMENT

THIS REPORT TO BE SUBMITTED WITHIN 60 DAYS AFTER WELL COMPLETION TO:

DIRECTOR OF TECHNICAL SERVICES
ALBERTA ENVIRONMENT

(1) CONTRACTOR

NAME

ADDRESS

LICENCE NO

DATE STARTED 19

DATE COMPLETED 19

WELL COMPLETION DATA

(2) DESIGN:

OPEN HOLE SLOTTED CASING

SCREEN GRAVEL PACK

DIAMETER OF HOLE

BOTTOMED IN: CLAY SAND

SANDSTONE SHALE COAL

DEPTH TO TOP OF BEDROCK

TOTAL DEPTH

(3) CASING:

TYPE

SIZE O.D WALL THICKNESS

BOTTOM SET AT FT/M

(4) SEAL: YES ☐ NO ☐

DEPTH OF SEAL FT/M

DESCRIPTION

(5) LINER YES ☐ NO ☐

TYPE

SIZE O.D

WALL THICKNESS

BOTTOM AT FT/M TOP AT FT/M

PERFORATED FROM FT/M TO FT/M

HOW PERFORATED TORCH ☐

MACHINE ☐ OTHER ☐

SIZE PERFORATIONS IN/MM BY IN/MM

(6) GRAVEL PACK YES ☐ NO ☐

SIZE AMOUNT

(7) SCREEN YES ☐ NO ☐

MATERIAL

SIZE I.D. (CLEAR)

LENGTH

SLOT SIZE

SCREEN FROM FT/M TO FT/M

FITTINGS TOP

FITTINGS BOTTOM

METHOD OF INSTALLATION

(8) PUMP YES ☐ NO ☐

TYPE H.P.

SIZE VOLTAGE

DROP PIPE SIZE LENGTH

MATERIAL

INTAKE AT FT/M

(9) WELL OWNER

NAME

ADDRESS

(10) LOCATION

1/4	SEC.	TWP	RGE	MERIDIAN

MEASUREMENTS SPECIFIED IN IMPERIAL ☐ OR METRIC ☐

(11) ILLUSTRATION OF WELL CONSTRUCTION

(12) FORMATION LOG DESCRIPTION

DEPTH FROM	DEPTH TO	
GROUND LEVEL		

(13) ELECTRIC LOG YES ☐ NO ☐

GAMMA LOG YES ☐ NO ☐

(14) TYPE OF WELL:

ROTARY ☐ BORED ☐ CABLE TOOL ☐

JET ☐ DUG ☐ OTHER ☐

(15) TYPE OF WORK:

NEW WELL ☐ DEEPEN ☐ TEST HOLE ☐

RECONDITION ☐ ABANDON ☐

(16) PROPOSED USE:

DOMESTIC ☐ STOCK ☐ IRRIGATION ☐

MUNICIPAL ☐ INDUSTRIAL ☐ OBSERVATION ☐

(17) PRODUCTION TEST (PUMPING AT A CONSTANT RATE)

TIME	WATER LEVEL BEFORE PUMPING FT/M	WATER LEVEL RECOVERY FT/M
0		
30 SEC		
1 MIN		
1 MIN. 30 SEC		
2 MIN		
3		
4		
5		
6		
7		
8		
9		
10		
12		
14		
16		
18		
20		
25		
30		
35		
40		
50		
60		
75		
90		
105		
120		

PUMP ☐ BAILER ☐ AIR ☐

NON PUMPING WATER LEVEL FT/M

RATE OF PUMPING I.G.P.M./L.P.M.

DURATION OF TEST (MIN. 2 HR. TEST) HRS MINS

PUMPING WATER LEVEL OR BAILING LEVEL FT/M

TOTAL DRAWDOWN AT END OF TEST FT/M

PUMP SET AT FT/M

ADDITIONAL PRODUCTION TEST INFO. YES/NO

RECOMMENDED PUMPING RATE I.G.P.M./L.P.M.

(18) WATER QUALITY

CHEMICAL ANALYSIS YES ☐ NO ☐

BACTERIAL ANALYSIS YES ☐ NO ☐

WATER TEMPERATURE

OTHER

CERTIFICATION
WATER WELL DRILLER (OPERATOR)

THIS WELL WAS CONSTRUCTED UNDER MY DIRECT SUPERVISION AND ALL INFORMATION GIVEN IS TRUE TO THE BEST OF MY KNOWLEDGE AND BELIEF. A COPY OF THIS REPORT HAS BEEN SUPPLIED TO THE OWNER.

SIGNATURE _____

JOURNEYMAN NO. _____ DATE _____ 19____

WELL OWNER

ANTICIPATED WATER REQUIREMENT

_____ GALLONS/LITRES PER DAY

I HAVE RECEIVED A COPY OF THIS REPORT.

SIGNATURE _____

DATE _____ 19____

ALBERTA ENVIRONMENT COPY

Province of British Columbia Ministry of Environment and Parks Water Management Branch

WATER WELL RECORD

Date

NTS MAP | Well No | ELEV | Location Accuracy

UTM Z E N | UTM Date 19 | Well Type

Owners Name & Address

Legal Description & Address

Descriptive Location

1. TYPE OF WORK 1 ☐ New Well 2 ☐ Reconditioned 3 ☐ Deepened 4 ☐ Abandoned

2. WORK METHOD 1 ☐ Cable tool 2 ☐ Bored 3 ☐ Jetted 4 ☐ Rotary a ☐ mud b ☐ air c ☐ reverse ☐ Other

3. WATER WELL USE 1 ☐ Domestic 2 ☐ Municipal 3 ☐ Irrigation 4 ☐ Comm & Ind ☐ Other

4. DRILLING ADDITIVES

5. MEASUREMENTS from 1 ☐ ground level 2 ☐ top of casing

casing height above ground level ft

FROM ft	TO ft	6. WELL LOG DESCRIPTION	SWL ft

7. CONSULTANT

Address

8. WELL LOCATION SKETCH

9. CASING: Materials 1 ☐ Steel 2 ☐ Galvanized 3 ☐ Wood 4 ☐ Plastic 5 ☐ Concrete ☐ Other

Hole Diameter							units
Diameter							ins
from							ft
to							ft
Thickness							ins
Weight							lb/ft

Pitless unit ft 1 ☐ above 2 ☐ below ground level

1 ☐ Welded 2 ☐ Cemented 3 ☐ Threaded 1 ☐ New 2 ☐ Used

Perforations

Shoe (s)

Open hole, from to ft Diameter ins

Grout

10. SCREEN: 1 ☐ Nominal (Telescope) 2 ☐ Pipe Size

Type 1 ☐ Continuous Slot 2 ☐ Perforated 3 ☐ Louvre ☐ Other

Material 1 ☐ Stainless Steel 2 ☐ Plastic ☐ Other

Set from to ft below ground level

RISER, SCREEN & BLANKS							units
Length							ft
Diam I D							ins
Slot Size							ins
from							ft
to							ft

Fittings, top bottom

Gravel Pack

11. DEVELOPED BY: 1 ☐ Surging 2 ☐ Jetting 3 ☐ Air 4 ☐ Bailing 5 ☐ Pumping ☐ Other

12. TEST 1 ☐ Pump 2 ☐ Bail 3 ☐ Air Date

Rate USgpm Temp °C SWL before test ft

Water Level ft after test of hrs

DRAWDOWN in ft				RECOVERY in ft			
mins	WL	mins	WL	mins	WL	mins	WL

13. RECOMMENDED PUMP TYPE | RECOMMENDED SETTING | RECOMMENDED PUMPING RATE ft USgpm

14. WATER TYPE: 1 ☐ fresh 2 ☐ salty 3 ☐ clear 4 ☐ cloudy

colour smell ; gas 1 ☐ yes 2 ☐ no

15. WATER ANALYSIS: 1 Hardness mg/L

2 Iron mg/L 3 Chloride mg/L

4 pH Field Date

SITE I D No Lab Date

16. FINAL WELL COMPLETION DATA

Well Depth ft Well Yield US gpm

Static Water Level ft Artesian Flow US gpm Artesian Pressure ft

Back filled

Well Head Completion

17. DRILLER PLEASE PRINT SURNAME FIRST NAME

Signature

18. CONTRACTOR.

Address

Member, BCWWDA ☐ yes ☐ no ,

Annex 3

Format of Well Data from Retrieval Systems

	Page
Newfoundland	68
Prince Edward Island	69
Nova Scotia	70
New Brunswick	71
Quebec	na
Ontario	72
Manitoba	73
Saskatchewan	74
Alberta	75
British Columbia	76
Yukon	na
Northwest Territories	na

FORM C
DEPARTMENT OF ENVIRONMENT
PROVINCE OF NEWFOUNDLAND

WATER WELL RECORD

13043

Print or Type

OWNER OF WELL

Name: Conception Harbour Town Council.
Address:
Date Completed: Day 01 Mo. 09 Yr. 87

LOCATION OF WELL

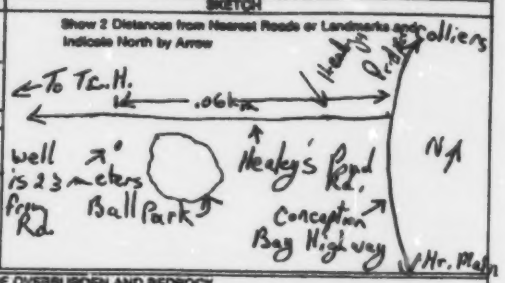
District: Conception Hr.
Town: Conception Hr.
Index Map. No.: 1N/6
Co-ordinates: 5256225N 332200E

DRILLER

Name (Signed): Robert Field
Address: Torbay
License No.: .006
Submission Date: Day ____ Mo. ____ Yr. ____

SKETCH

Show 2 Distances from Nearest Roads or Landmarks and Indicate North by Arrow



STRATIGRAPHIC LOG OF OVERBURDEN AND BEDROCK

Depth - metre From	Depth - metre To	General Color	Most Common Material	Other Materials	General Description
0m	17m	Gray	Gravel		Loose with Some water in the First 4 meters.
17m	45.5m	Red	Red Rock	Small touch of Gray Rock at Bottom of Hole.	Very Hard with No Fractures. Elev. 40 m.

TYPE OF WELL

Method of Drilling: ☐ Cable Tool ☐ Rotary (Conventional) ☐ Rotary (Reverse) ☑ Rotary Air ☐ Air ☐ Boring ☐ Diamond ☐ Jetting ☐ Driving

Casing-Open Hole: Inside Dia. mm	Material	Depth - metre From	Depth - metre To
200mm	Casing / Open Hole	0m	17m
150mm	Casing / Open Hole	0m	17m
150mm	Casing / Open Hole	0m	45.5m

Screen: Size(s) of Opening (Slot No.): ____ Slotted Casing: ____ Diameter mm: ____ Length metre: ____ Material and Type: ____ Depth to top of Screen metre: ____

Total Depth Below Surface: 45.5m metre
Casing Setting: Cemented ☐ Driven ☐ Loose ☑ Packer ☐
Diameter at Lowest Level: 150mm mm

WATER OCCURRENCE

Water Found at - metre	Kind of Water		
29m	☑ Fresh ☐ Salty	☐ Sulfur ☐ Mineral	
	☐ Fresh ☐ Salty	☐ Sulfur ☐ Mineral	
	☐ Fresh ☐ Salty	☐ Sulfur ☐ Mineral	
	☐ Fresh ☐ Salty	☐ Sulfur ☐ Mineral	

Well Development: Surged ☐ Acidized ☐ Flushed ☐ Other ☐

PUMPING TEST

Pumping Test Method: ☐ Pump ☐ Bailer
Pumping Rate: 12.0 L/min
Duration of Pumping: ____ h 45 min
Static Water Level: 3.52m / 7.09 metre
Drawdown: ____ metre
If Flowing Give Rate: ____ L/min
Water Levels During Pumping: 15 min ____ 30 min ____ 45 min ____ 60 min ____ metre
Water Levels During Recovery: 15 min ____ 30 min ____ 45 min ____ 60 min ____ metre
Water Level at End of Pumping: ____ metre
Water at End of Test: ☐ Clear ☐ Cloudy
Pump Intake Set at: ____ metre
Recommended Pump Type: ☐ Shallow ☑ Deep
Recommended Pump Setting: ____ metre
Recommended Pumping Rate: ____ L/min

QUALITY OF WATER

Color	Odor	Turbidity	Hardness	Chemicals Above Canadian Standards	Sample Taken
☑ None ☐ Red ☐ Brown ☐ Other	☑ None ☐ Gas ☐ Sulfur ☐ Other	☑ Clear ☐ Silty ☐ Sandy ☐ Cloudy	☐ Soft ☐ Medium ☐ Hard	☐ Iron ☐ Manganese ☐ Other	☐ Yes ☐ No Attach Results of Analysis

FINAL STATUS OF WELL

☑ Water Supply
☐ Observation Hole
☐ Test Hole
☐ Abandoned - Insufficient Supply
☐ Abandoned - Poor Quality
☐ Unfinished

WATER USE

☐ Domestic ☐ Industrial
☐ Public Supply ☐ Commercial
☑ Municipal ☐ Other

SHEET 1 WHITE - DEPARTMENT COPY; SHEET 2 PINK - DRILLERS' COPY; SHEET 3 BLUE - OWNER'S COPY

WATER WELLS

DEPARTMENT OF COMMUNITY AFFAIRS
WATER RESOURCES BRANCH

SERIAL

TRANSACTION TYPE
A - Add
C - Change
D - Delete

Type
Owner
Location
Easting Northing Ground Elevation

Building Permit
Date of Completion y y m m d d
Driller Company
Driller Person
Reliability Method

Well Depth
Diameter 1
Diameter 2
Casing Material
Casing Diameter
From To
From To

Water Occurrence
1 From To
2
3
4
5
6
7
8
9

Water Quality
Type of Yield Test Rate Hours Minutes
Drawdown
Specific Capacity
Recovery
Static Water level
Comments

Stratigraphic Log

	From		To		Adjective				Noun
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									

M.T.	Rel. Map	S.T. Map	Owner	Driller License No.	Well Depth (ft.)	Water Depth (ft.)	Hole Diam. (in.)	Csg. Lgth. (ft.)	Use	Qual.	Sur. Elev. (ft.) Aquifer	Pump or Bail Test	Lithologic Log and Remarks
66	A	10	Johnson, George	2	65	16	4	21	D	Clear		6 - 5 gpm - 1 hr DD-58' - 1 hr Rec-41' - 1 min	0-16 O/B; 16-65 gray sh
66	A	10	Pellarine, Walter	2	165	60	5	42	D	Clear		P - 3 gpm - 1 hr DD-137' - 1 hr Rec-134' - 1 min	0-36 O/B; 36-85 gray sh 85-110 black coal sh; 110-165 gray sh
67	A	10	MacBeth, Jackie	4	198	10	5	22	D			P - 1 gpm - 1 hr DD-198' - 1 hr Rec-147' - 1 hr	0-17 cl & bldrs; 17-105 gray sh 105' - 130 black sl; 130-198 black sh
67	A	10	Oliver, John Robert	4	80	17	5	29	D			P - 7 gpm - 1 hr DD-80' - 1 hr Rec-35' - 10 mins	0-12 cl & bldrs; 12-80 gray sh
67	A	10	Tracey, Pat	4	173	20	6	42	D			P - 1 1/2 gpm - 1 hr DD 173' - 1 hr Rec-153' - 30 mins	0 20 mud, gr; 20-173 gray sh
69	A	10	Vincent, Geo.	80	100	40	4	49				6 gpm DD-60' Rec-40' - 8 mins	0-46 coal, slate; 46-100 gray ss
69	A	10	Murray, Ernest	80	77	30	4	44	D			P - 5 gpm DD-40' Rec-30' - 5 mins	0-35 cl & gr; 35-55 blue ss; 55 58 gray sl 58-77 blue ss
71	A	10	MacLellan, Raymond	4	72	10	5	26	D			P - 3 gpm - 1 hr DD-71' - 1 hr Rec-25' - 5 mins	0-18 mud & bldrs; 18-72 red sh
73	A	10	East Pictou School # 2	2	200	28	6	32	P	Clear		P - 30 gpm - 1 hr DD-150' - 1 hr Rec-125' - 1 min	0-29 O/B; 29-40 gray ss 40-72 red ss; 72-80 gray ss; 80-160 red ss 160-200 gray ss
74	A	10	Murray, Ernest C.	2	85	25	5	22	D			5 gpm - 1 hr DD-76' - 1 hr Rec-70' - 1 min	0-12 O/B; 12-85 gray ss
75	A	10	Richards, Bobby	2	85	18	5	21	D	Clear		P - 5 gpm - 1 hr DD-75' - 1 hr Rec-69' - 1 min	0-15 O/B; 15-85 red sh
75	A	10	Stewart, Robert	2	115	30	5	42	D	Clear		P - 2 gpm - 1 hr DD-92 1/2' - 1 hr Rec-90'	0-35 O/B; 35-84 red sh 84-115 gray sh
76	A	10	Redmond, Charles	2	130	35	5	62	D	Clear		P - 3 gpm - 1 hr DD-125' - 1 hr Rec-121' - 1 min	0-42 O/B; 42-60 soft red sh 60-130 red sh
77	A	10	Urquhart, Doug	2	50	20	5	22	D			5 gpm - 1 hr DD-45' - 1 hr Rec-39' - 1 min	0-15 O/B, 15-40 gray ss; 40-50 red ss
77	A	10	MacDonald, Graham	2	90	10	5	22	D			12 gpm - 1 hr DD-85' - 1 hr Rec-70' - 1 min	0-10 O/B, 10-75 red sh; 75-90 gray sh
77	A	10	MacDonald, Jack	2	65	18	5	24	D			21/2 gpm - 1 hr DD-45' - 1 hr Rec-42' - 1 min	0-18 O/B; 18-65 red sh
78	A	10	MacDonald, Frank	2	65	18	5	22	D	Clear		P - 5 gpm - 1 hr DD-56 1/2' - 1 hr Rec-50' - 1 min	0-15 O/B; 15-58 gray ss; 58-65 red ss
78	A	10	MacDonald, Allister	2	65	18	5	22	D	Clear		P - 5 gpm - 1 hr DD-56 1/2' - 1 hr Rec-50' - 1 min	0-15 O/B; 15-58 gray ss 58-65 red ss
80	A	10	Bruce, George	2	140	45	5	44	D	Clear		P- 21/2 gpm - 1 hr DD-87' - 1 hr Rec-84' - 1 min	0-35 O/B; 35-80 gray sh, 80-98 gray ss 98-140 gray sh
81	A	10	LeFresne, Howard	4	179	5	5	22	D			P - 3 gpm - 1 hr DD-178' - 1 hr Rec-100' - 17 mins	0-12 mud & bldrs; 12-179 hard red sh
81	A	10	Green, Vernon	4	198	30	6	22	D			P - 1/2 gpm - 1 hr DD-198' - 1 hr Rec-148' - 40 mins	0-1 mud & bldrs; 16-198 red sh
81	A	10	Cameron, W. D. (Mrs.)	4	96	20	5	24	D			P - 4 1/2 gpm - 1 hr DD-96' - 1 hr Rec-60' -15 mins	0-16 mud & bldrs; 16-96 gray sh

87/DEC/17 MUNICIPAL AFFAIRS AND ENVIRONMENT WATER WELL DATA

DETAILED INFORMATION REPORT

SEQUENCE NO.	: 79 3817	ATLAS PAGE	: 13	TOTAL DEPTH	: 78
OWNER NAME	: YVON L DUCLOS	REFERENCE MAP	: J 06	EST. SAFE YIELD	: 0
OWNER ADDR.	: BOX 25	EAST COORDINATES	: 28	PUMP DURATION	: 0 HRS 0 MNS
OWNER TOWN	: ST ISIDORE	NORTH COORDINATES	: 16	FINAL WATER LEVEL	: 0 FT 0 INS
OWNER PHONE	: 000-0000	UTM ZONE	: 20	SPECIFIC CAPACITY	: 0
COMPANY NAME	: BERUBE BROS LTD	UTM EASTING	: 347650	DEPTH TO BEDROCK	: 72
LICENSE NO.	: 060	UTM NORTHING	: 5268950	CASING DIAMETER	: 6 INS
DATE COMPLETED	: 79/JUN/29				

DRILL METHOD : 3 (ROTARY-AIR)
DEV. METHOD : 1 (AIR LIFT)
WATER USE : 1 (DOMESTIC)
FINAL STATUS : 1 (WATER SUPPLY)

COMMENTS :

DRILLERS LOG

DEPTH	COLOR	DESCRIPTION	GROUND	DESCRIPTION
0	1	(BROWN)	03	(TOPSOIL)
90	1	(BROWN)	09	(CLAY)
72	8	(BLACK,GREY)	13	(SNDST/MED*FI)

MUNICIPALITY CONCESSION ETC	LOT	WELL NO	UTM EASTING NORTHING	ELEV FEET	DATE	DRILLER	CSG DIA INS	KIND OF WATER	WATER FOUND FEET	STAT LVL FEET	PUMP LVL FEET	TEST RATE GPM	TEST TIME HR/MN	WATER USE	OWNER/LOG DEPTHS IN FEET TO WHICH FORMATIONS EXTEND
CUMBERLAND TOWNSHIP															
CON 4	1	15-13078	439580 5036160	210	06/58	4216	4	SU	119	18	25	6	1/00	DO	HURLEY R CLAY 0035 SILT 0037 LMSN 0170
CON A	1	15-12887	466575 5039650	280	02/71	1504	6	FR	208	100	100	10	3/00	DO	DOSTALER M BLUE CLAY 0190 GREY BLDR GRVL 0198 GREY LMSN 0208
CON A	1	15-13073	466700 5039350	255	06/67	1504	5	FR	45	15	25	8	2/00	DO	EDGETT D BLUE CLAY 0040 GREY LMSN 0045
CON A	1	15-13072	466750 5039250	280	11/63	1504	2	FR	32	10	20	8	2/00	DO	STRAUSS J BLUE CLAY 0028 GRVL 0032
CON A	1	15-12888	466800 5039100	320	06/71	1504	2	FR	31	2	15	7	2/00	DO	MCINTOSH L BLUE CLAY 0028 GREY GRVL 0031
CON A	1	15-13071	466800 5039100	270	03/62	1504	2	FR	53	FLW	20	8	2/00	DO	BURGESS M BLUE CLAY 0038 GREY LMSN 0053
CON A	1	15-12889	466950 5038785	375	07/71	1802	6	FR	60	40	200	1	1/00	DO	FORD A D HPAN 0008 GREY LMSN 0200
CON A	1	15-11694	466950 5038800	380	08/71	1504	6	FR	141	10	75	2	2/00	DO	RANCOURT R GREY LMSN 0141
CON A	1	15-12897	473060 5040440	245	03/69	1802	6	FR	185	115	130	10	1/00	PS	PUBLIC SCHOOL BOARD MSND 0009 CLAY 0070 HPAN 0078 LMSN 0200
CON W	1	15-12983	459400 5036440	202	08/62	1632	2	FR	135	18	40	3	2/00	DO	PAQUETTE R BLUE CLAY 0135
CON W	1	15-13079	459420 5036440	203	01/60	2311	4	SU	81	12	20	5	1/00	DO	LEMAY G CLAY 0072 LMSN 0092
CON W	1	15-13080	459420 5036500	202	06/67	1504	2	FR	80	12	25	10	2/00	DO	FRONC T BLUE CLAY 0070 GRVL 0080
CON W	1	15-13075	459440 5036300	209	02/60	1504	3	FR	124	14	20	8	2/00	DO	PARKS AND GARDENS CO BLUE CLAY 0102 GREY LMSN 0124
CON W	1	15-13076	459520 5036290	211	11/60	3504	10	FR	98	18	80	65	48/00	HU	PARKS AND GARDENS CO BLUE CLAY 0098 CSND 0107
CON W	1	15-13210	459590 5036600	204	08/60	1504	2	FR	50	13	25	7	2/00	DO	HOUFKIN R BLUE CLAY 0047 GREY LMSN 0050
CON W	1	15-13077	459600 5035880	212	07/56	1107		FR	114	6	75	3	1/00	DO	GOUR A PROB 0074 LMSN 0114
CON	1	5 15-12414	474900 5035900	220	06/72	1504	6	FR	50	12	26	10	2/00	ST	BERTRAND R YLLW SAND 0027 GREY ROCK 0050
CON	1	8 15-12913	999999 9999999		06/49	3333	1	FR	24	FLW				ST	DUELLETTE L RED CLAY 0024 GRVL 0025 ROCK 0026
CON	1	12 15-12648	477060 5032800	275	06/70	1517	5	FR	40	12	25	10	1/00	DO	JOLLY Y GREY HPAN 0007 GREY ROCK SHLE 0018 GREY LMSN 0042
CON	1	12 15-12649	477070 5032750	275	06/70	1517	5	FR	41	12	25	10	1/00	DO	JOLLY Y BRWN SLTE HPAN 0007 GREY LMSN 0042
CON	1	16 15-12651	477860 5030060	260	03/53	1526	5	FR		12	22	4	2/00	ST DO	LAPLANTE G WHIT CLAY 0060 GRVL 0062
CON	1	24 15-13115	478560 5025200	215	10/65	1504	5	FR	69	10	30	6	3/00	DO	LAVIENE J BLUE CLAY 0066 BRWN SLTE 0069
CON	2	6 15-	474500	225	12/68	1504	2	FR	51	4	25	5	2/00	ST DO	BERTRAND AURELIEN

Additional information concerning length, screen, drilling method and well plugging are available upon request from the regional office (detailed under approximately fifty headings).

LOCATION - SE08-15-09E

Owner - S WALLIS
Well ID -
Date Completed - May/11/76

Driller - PAUL SLUSARCHUK DRILLING LTD.
Well Use - Production
Water Use - Domestic

WELL LOG (Metric Units)

From	To (m)	Log
0.0	3.7	CLAY
3.7	10.4	GREY CLAY& BOULDERS
10.4	15.2	CLAY, SAND, GRAVEL& GRANITE BOULDERS

Aquifer - SG

WELL CONSTRUCTION

From	To (m)	Inside Dia.(mm)	Outside Dia.(mm)	Screen Slot Size (mm)	Type	Material
0.0	12.6 casing	127			T & C	GALVANIZED
12.6	14.2 perforations		127	0.46	WIRE WOUND	
11.9	15.2 gravel pack					

Top of Casing - 0.0 m below ground

PUMPING TEST

Date -
Rate = 0.11 Litres/second
Water level before pumping: 0.91 m above ground
Pumping level at end of test: m below ground
Test duration: 3 hours, minutes
Water temperature: ?? degrees C

LOCATION - SW08-15-09E

Owner - S WALLIS
Well ID -
Date Completed - Aug/17/88

Driller - ECHO DRILLING
Well Use - Production
Water Use - Domestic,Livestock

WELL LOG (Metric Units)

From	To (m)	Log
0.0	12.2	GREY TILL
12.2	19.8	SAND AND GRAVEL ; SILTY

Aquifer - SG

WELL CONSTRUCTION

From	To (m)	Inside Dia.(mm)	Outside Dia.(mm)	Screen Slot Size (mm)	Type	Material
0.0	14.0 casing	107			INSERT	BLACK IRON
14.0	17.1 perforations	102		0.38	WIRE WOUND	S. S.

Top of Casing - 0.6 m above ground

PUMPING TEST

Date : Aug 17 88
Pumping @ 0.30 Litres/second
Water level before pumping: 1.52 m below ground
Pumping level at end of test: 16.46 m below ground
Test duration: 1 hours, minutes
Water temperature: ?? degrees C

LOCATION - SW09-15-09E

Owner - J WOLIGROSKI
Well ID -
Date Completed - May/15/86

Driller - FRIESEN DRILLERS LTD.
Well Use - Production
Water Use - Domestic

WELL LOG (Metric Units)

From	To (m)	Log
0.0	1.8	CLAY ; GREY
1.8	9.1	SAND ; FINE
9.1	15.8	SAND AND GRAVEL ; LAYER OF CLAY

Aquifer - SG

WELL CONSTRUCTION

From	To (m)	Inside Dia.(mm)	Outside Dia.(mm)	Screen Slot Size (mm)	Type	Material
0.0	12.5 casing	104			INSERT	BLACK IRON
12.5	14.0 perforations	102		0.38	WIRE WOUND	S. S.

Top of Casing - 0.0 m below ground

PUMPING TEST

Date : May 15 86
Pumping @ 0.38 Litres/second
Water level before pumping: 0.61 m below ground
Pumping level at end of test: 13.72 m below ground
Test duration: hours, 30 minutes
Water temperature: ?? degrees C

SASKATCHEWAN DEPARTMENT OF THE ENVIRONMENT
GROUND WATER DATA REPORT

M 15

FILE NO 09A77 | Owner | Driller | Hole | DD MM YY

QTR | SEC | TWP | RGE | MER | Method | Completion | Dia | Depth Total | Depth Struck | WL | Head

Feet From | Boundary

Water Use | Well Use | Pump Test: Drawdown, Hrs, GPM | Recommended: GPM, Interval | Temp °F

Map No: NTS | PHYS | Basin No: MAJ | SUB

Elev | Spec Cap | Hyd Cond | Co Trans | Co Stor | AOF | Elec Log

Lnth	Btm	Dia	Description	
				Well Casing

Btm	Dia	Slot	Lnth	Description	
					Well Screen or Perforation

Depth	Material	Colour	Description
174	SAND	GREY	NONCALCAREOUS
191	SILT	GREY	NONCALCAREOUS
228	CLAY	GREY	NONCALCAREOUS

Note

Chemical Analysis: MM YY | Lab | ACO No

Tot Hard	Cl
Cal Hard	SO_4
Fe	NO_3
Mn	Fl
Ca	TDS
Mg	Tot Alk
Na	Cond
HCO_3	pH
CO_3	

FILE NO 66625 | Owner: KOSTIUK HOLDINGS LTD, LLOYDMINSTER | Driller: STAN BYRI AND SONS | Hole: 1 | DD MM YY: 12 05 75

SW 02 50 28 3 | Method: DRILLED | Completion | Dia | Depth Total: 201 | Depth Struck | WL | Head

Feet From | Boundary

Water Use: DOMESTIC | Well Use: WATER TH | Pump Test | Recommended | Temp °F

Map No: NTS 73F | PHYS E05 | Basin No: MAJ 07 | SUB 29

Elev 2100 | Spec Cap | Hyd Cond | Co Trans | Co Stor | AOF | Elec Log No

Lnth	Btm	Dia	Description	
				Well Casing

Btm	Dia	Slot	Lnth	Description	
					Well Screen or Perforation

Depth	Material	Colour	Description
2	FILL		
17	TILL	BROWN	
81	TILL	GREY	
86	SAND	GREY	COARSE
111	SILT	GREY	
139	TILL	GREY	
146	SAND & GRVL	BROWN	
159	GRAVEL		
162	SHALE	GREY	
201	SANDSTONE	GREY	SHALE STREAKS

NOTE:

Chemical Analysis: MM YY | Lab | ACO No

Tot Hard	Cl
Cal Hard	SO_4
Fe	NO_3
Mn	Fl
Ca	TDS
Mg	Tot Alk
Na	Cond
HCO_3	pH
CO_3	

FILE NO 66676 | Owner: KOSTIUK HOLDINGS LTD, LLOYDMINSTER | Driller: STAN BYRI AND SONS | Hole: 2 | DD MM YY: 12 05 75

SW 02 50 28 3 | Method: DRILLED | Completion: OPEN HOLE | Dia: 6.7 | Depth Total: 183 | Depth Struck: 140 | WL: 66 | Head

Feet From | Boundary

Water Use: INDUSTRIAL | Well Use: WITHDRAWAL | Pump Test: Drawdown 48.7, Hrs 2, GPM 11 | Recommended: GPM 12, Interval 150 | Temp °F

Map No: NTS 73F | PHYS E05 | Basin No: MAJ 07 | SUB 29

Elev 2100 | Spec Cap 0.2 | Hyd Cond | Co Trans | Co Stor | AOF GLACIAL | Elec Log No

Lnth	Btm	Dia	Description	
	162	55	BLACK IRON	Well Casing

Btm	Dia	Slot	Lnth	Description	
					Well Screen or Perforation

Depth	Material	Colour	Description
2	TOPSOIL		
17	TILL	BROWN	
81	TILL	GREY	
86	SAND	GREY	COARSE
111	SILT	GREY	
139	TILL	GREY	
146	SAND & GRVL	BROWN	MUDDY
159	GRAVEL		MUDDY
162	SHALE	GREY	
183	SANDSTONE		

NOTE:

Chemical Analysis: MM YY | Lab | ACO No

Tot Hard	Cl
Cal Hard	SO_4
Fe	NO_3
Mn	Fl
Ca	TDS
Mg	Tot Alk
Na	Cond
HCO_3	pH
CO_3	

FILE NO 74808 | Owner: GORDON MEVILLE, BOX 952 LLOYD SASK | Driller: MCALLISTER DRILLING | Hole: 1 | DD MM YY: 28 06 83

NW 07 50 28 3 | Method: DRILLED | Completion: SCREEN | Dia: 6.2 | Depth Total: 80 | Depth Struck: 51 | WL | Head

2500 Feet N | 2000 From W | Boundary

Water Use: DOMESTIC | Well Use: WITHDRAWAL | Pump Test: Drawdown 65.0, Hrs 2, GPM 12 | Recommended: GPM 8, Interval 67 | Temp °F

Map No: NTS 73F | PHYS E05 | Basin No: MAJ 07 | SUB 29

Elev 2075 | Spec Cap 0.2 | Hyd Cond | Co Trans | Co Stor | AOF GLACIAL | Elec Log No

Lnth	Btm	Dia	Description	
73	71	45	BLACK IRON	Well Casing

Btm	Dia	Slot	Lnth	Description	
75	40	15	4	STAINLESS STEEL	Well Screen or Perforation

Depth	Material	Colour	Description
1	TOPSOIL		
38	SAND	BROWN	
80	SAND & GRVL	GREY	FINE

NOTE

Chemical Analysis: MM YY | Lab | ACO No

Tot Hard	Cl
Cal Hard	SO_4
Fe	NO_3
Mn	Fl
Ca	TDS
Mg	Tot Alk
Na	Cond
HCO_3	pH
CO_3	

GTS 78-1489

ALBERTA ENVIRONMENT
GROUND WATER WELL DATA (GWWD) SYSTEM
RETRIEVAL 1 - INDEX DATA - FRED EVANS

PRINTED ON MAY 17, 1988

FROM: JAN 1900 TO: MAY 1988
FROM: ---------001-01W4 TO: ---------126-15W6

TYPE: 55 DRILLER: a FTD FROM: .0 FTD TO: .0 ELECTRIC GAMMA LITHO a CHEM a CERT

N	LOCATION LOC EX	LSD	SEC	TWP	RGE	M	DRILLER	COMPLETION DATE (DAY MO. YEAR)	FINAL TOTAL DEPTH (FT.)	LOG	STATIC WATER LEVEL (FT)	FLOWING SHOT HOLE FROM DEPTH(FT)	LITHO (INT)	CHEM (NO)	CERT KEY	MCR IND
1	02	SE-	20-	039-	14-	4	HI-RATE DRLG	26 AUG 1981	100.0	-----	FL	--	8	---	-	00
1	00	SE-	36-	039-	18-	4	FORRESTER WW BORING	-- --- ----	225.0	-----	FL	--	---	1	.	00
1	01	NE-	01-	039-	19-	4	ROBBINS ERNEST G	06 DEC 1959	53.0	-----	FL	--	7	---	*	00
2	07	NW-	15-	039-	19-	4	LOUSANA WATER WELLS	19 DEC 1985	500.0	-----	FL	--	4	---	+	07
3	05	SE-	27-	039-	19-	4	ROSS DRILLING	25 JUL 1981	95.0	-----	FL	--	4	---	-	00
4	06	SE-	27-	039-	19-	4	ROSS DRILLING	20 DEC 1981	255.0	-----	FL	--	10	---	*	00
5	02	04-	28-	039-	19-	4	HEER MANUEL D	18 AUG 1969	100.0	-----	FL	--	5	---	.	00
1	14	09-	01-	039-	20-	4	CORNELSSEN L R	-- --- 1953	62.0	-----	FL	--	3	---	*	00
2	00	NW-	35-	039-	20-	4	CORNELSSEN L R	-- --- 1960	160.0	-----	FL	--	5	---	*	00
1	00	13-	19-	039-	23-	4	-----	-- --- 1921	100.0	-----	FL	--	---	---	-	00
2	01	NW-	30-	039-	23-	4	GREEN TED	16 APR 1964	109.0	-----	FL	--	6	---	*	00
1	00	---	16-	039-	24-	4	SIEBLE ALLAN	12 SEP 1970	130.0	-----	FL	--	4	---	*	00
2	08	NW-	19-	039-	24-	4	J & R DRLG	30 NOV 1982	60.0	-----	FL	--	3	---	.	01
3	11	NW-	20-	039-	24-	4	J & R DRLG	30 NOV 1982	55.0	-----	FL	--	4	---	.	01
4	00	SW-	35-	039-	24-	4	SCHMIDT DRLG (DON)	08 APR 1967	90.0	-----	FL	--	2	---	.	00
5	01	SW-	35-	039-	24-	4	SCHMIDT DRLG (DON)	09 AUG 1978	140.0	-----	FL	--	5	2	.	00
6	04	SW-	35-	039-	24-	4	SCHMIDT DRLG (DON)	22 JUL 1986	100.0	-----	FL	--	4	---	+	08
1	05	SW-	09-	039-	25-	4	SCHMIDT DRLG (DON)	15 JUL 1968	45.0	-----	FL	--	2	---	.	00
2	03	13-	09-	039-	25-	4	SCHMIDT DRLG (DON)	12 AUG 1967	40.0	-----	FL	--	2	---	.	00
3	05	NE-	17-	039-	25-	4	SCHMIDT DRLG (DON)	08 DEC 1967	40.0	-----	FL	--	2	---	.	00
4	00	NE-	29-	039-	25-	4	-----	12 OCT 1972	60.0	-----	FL	--	---	---	.	00
1	03	NW-	28-	039-	28-	4	FORRESTER WW BORING	18 OCT 1979	90.0	-----	FL	--	10	---	*	00
1	29	---	03-	040-	05-	4	-----	31 OCT 1970	16.6	-----	FL	--	---	---	.	00
1	00	SE-	35-	040-	07-	4	-----	-- --- ----	204.0	-----	FL	--	---	2	.	00
2	01	NE-	35-	040-	07-	4	MCALLISTER DRLG	16 NOV 1979	206.0	EL---	FL	--	12	---	*	00
1	06	SE-	34-	040-	11-	4	-----	-- --- ----	200.0	-----	FL	--	---	1	*	00
1	01	SE-	32-	040-	19-	4	-----	-- --- ----	34.0	-----	FL	--	---	1	*	00
1	00	08-	36-	040-	20-	4	WINTER R A	09 MAY 1968	150.0	-----	FL	--	8	---	*	00
1	00	NW-	15-	040-	22-	4	WINTER PAUL L	15 OCT 1972	150.0	-----	FL	--	11	---	*	00
2	02	SE-	22-	040-	22-	4	WINTER PAUL L	25 APR 1972	165.0	-----	FL	--	7	---	.	00
3	02	NW-	33-	040-	22-	4	WINTER PAUL L	-- AUG 1969	80.0	-----	FL	--	3	---	*	00
4	07	SE-	34-	040-	22-	4	-----	-- --- ----	75.0	-----	FL	--	---	1	*	00
5	06	SW-	34-	040-	22-	4	-----	-- --- ----	170.0	-----	FL	--	---	1	*	00
1	02	NW-	02-	040-	23-	4	SCHMIDT DRLG (DON)	23 JUL 1979	49.0	-----	FL	--	3	---	*	00
2	01	NW-	03-	040-	23-	4	-----	-- --- ----	40.0	-----	FL	--	---	1	*	00

Ministry of Environment and Parks - Water Management Branch - Groundwater Section
Groundwater Database System
Data Summary

BCGS Map Area	Well No.	Owner's Name	Date Constructed (day)	Well Depth (ft.)	Well Diam. (in.)	Well Yield	Yld. Unt.	Depth to Water (ft.)	Depth to Bedrk (ft.)	Aquif Litho	Screen Interval (ft.)
082E.033.3.1.4	001	DAVID B SCOTT	01-01-50	119.0	6.0	10.0	GPM	51	UNK	UNC	
082E.033.3.1.4	002	W BARTEN	05-04-63	32.0	36.0			23	UNK	UNC	
082E.033.3.1.4	003	EUGENE CZUZCOR	13-01-69	98.0	8.0	2.0	GPM	57	56	BED	
082E.033.3.1.4	004	EUGENE CZUZCOR	14-01-69	98.0	8.0	5.0	GPM	57	56	BED	
082E.033.3.1.4	005	TURPIN	01-06-70	146.0	6.0	8.0	GPM	30	2	BED	
082E.033.3.1.4	006	SUNNY BAY RESORT	01-11-73	34.0	0.0	12.0	GPM	UNK	UNK	UNC	
082E.033.3.1.4	007	J OLIVIER	20-08-76	40.0	6.0	20.0	GPM	12	UNK	UNC	36-40
082E.033.3.1.4	008	J TURPIN	21-01-76	150.0	6.0	2.5	GPM	29	4	BED	
082E.033.3.1.4	009	MARGARET MICHIE	01-09-77	40.0	6.0	5.0	GPM	5	UNK	UNC	29-34
082E.033.3.1.4	010	GERRY MCFADYEN	30-03-77	30.0	6.0	70.0	GPM	1	3	BED	
082E.033.3.1.4	011	JOHN OLIVER	01-06-76	47.0	6.0	25.0	GPM	9	47	UNC	40-45
082E.033.3.1.4	012	W C PARKER	27-04-78	645.0	6.0	8.0	GPM	124	2	UNC	
082E.033.3.1.4	013	INTERNATIONAL PARK W	07-12-78	213.0	6.0	10.0	GPM	66	0	BED	
082E.033.3.2.1	001	THOMAS RANCHES LTD	01-09-73	45.0	12.0	120.0	GPM	11	UNK	UNC	
082E.033.3.2.1	002	THOMAS RANCHES LTD	01-09-73	218.0	6.0	20.0	GPM	27	UNK	UNC	
082E.033.3.2.1	003	THOMAS RANCHES LTD	01-09-73	188.0	8.0			UNK	UNK	UNC	
082E.033.3.2.3	001	GERRY SISMEY	01-11-79	665.0	6.0	1.0	GPM	80	33	BED	
082E.033.3.2.3	002	GERRY SISMEY	01-01-80	415.0	6.0	1.0	GPM	60	3	BED	
082E.033.3.2.3	003	TOM STAMP	01-09-84	380.0	6.0	3.0	GPM	50	5	BED	
082E.033.3.2.3	004	CHRIS PEARCE	01-02-84	140.0	6.0	15.0	GPM	25	7	BED	
082E.033.3.2.3	005	E HYNDMAN	01-01-54	120.0	6.5	6.5	GPM	UNK	27	BED	
082E.033.3.2.3	006		24-06-70	96.0	6.0	1.0	GPM	35	9	UNC	
082E.033.3.3.1	001	SCHORI	01-07-77	80.0	6.0	40.0	GPM	58	UNK	UNC	71-80
082E.033.3.3.1	002	E MARCHANT	01-07-77	69.0	6.0	60.0	GPM	40	UNK	UNC	63-68
082E.033.3.3.1	003	KALEDEN IRRIG DIST	19-09-79	134.0	8.0			13	UNK	UNC	95-133
082E.033.3.3.1	004	KALEDEN IRRIG DIST	01-03-82	303.0	6.0	6.0	GPM	270	10	BED	
082E.033.3.3.2	001	DR E M SLOAN	01-06-63	41.0	6.0	4.0	GPM	10	UNK	UNC	
082E.033.3.3.2	002	FRANK CHRISTIAN	01-04-73	138.0	6.0	30.0	GPM	12	UNK	UNC	
082E.033.3.3.2	003	A MATHESON	01-09-75	90.0	6.0	15.0	GPM	8	UNK	UNC	85-90
082E.033.3.3.2	004	MARK GIBSON	05-06-82	271.0	8.0	500.0	GPM	78	UNK	UNC	243-271
082E.033.3.3.2	005	DAVID SLOAN	01-04-81	149.0	6.0	8.0	GPM	45	UNK	UNC	143-148
082E.033.3.3.4	001	ART RICHARDSON	02-02-76	150.0	6.0	2.5	GPM	UNK	5	BED	
082E.033.3.3.4	002	E BADERTSCHER	29-04-80	650.0	6.0	10.0	GPM	10	31	BED	
082E.033.3.3.4	003	KEN CHARLISH	28-12-77	313.0	6.0	20.0	GPM	76	100	BED	
082E.033.3.3.4	004	M JOST	11-01-85	360.0	6.0	2.0	GPM	22	26	BED	
082E.033.3.4.1	001	GUY INKSTER	01-08-81	265.0	6.0	5.0	GPM	22	59	BED	
082E.033.3.4.1	002	FRANZ SPIELDIENER	01-11-78	565.0	6.0	2.0	GPM	108	15	BED	
082E.035.2.2.1	001	FRANK BLASKOVITS	16-05-70	72.0	6.0	50.0	GPM	6	UNK	UNC	
082E.042.2.2.2	001	GARY SHARPE	10-10-75	98.0	6.0	3.0	GPM	17	UNK	UNC	65-83
082E.042.2.2.2	002	PENTICTON INDIAN BD	06-11-79	107.0	6.0	0.5	GPM	91	106	UNC	
082E.042.2.2.2	003	OKANAGAN GAME FARM	01-03-78	210.0	6.0	40.0	GPM	17	22	BED	
082E.042.2.2.4	001	OKANAGAN GAME FARM	16-07-73	128.0	0.0			UNK	78	UNC	
082E.042.2.4.2	001	PENTICTON INDIAN BAN	25-11-79	149.0	6.0	45.0	GPM	96	UNK	UNC	140-149
082E.042.2.4.4	001	R WAITE OK AMUSEMENT	20-12-72	150.0	6.0	75.0	GPM	68	UNK	UNC	
082E.042.2.4.4	002	BILL FINK RIVA RIDGE	01-03-82	175.0	8.0	700.0	GPM	77	UNK	UNC	157-174
082E.042.4.2.2	001	KENYON & CO LTD	01-08-61	67.0	8.0	50.0	GPM	10	UNK	UNC	
082E.042.4.2.2	002	PENTICTON AIRPORT #1	01-09-42	45.5	0.0	24.0	GPM	4	UNK	UNC	
082E.042.4.2.2	003	J KRUGER	23-06-59	84.0	6.0	10.0	GPM	39	UNK	UNC	
082E.042.4.2.2	004	PINEAPPLE JUNCTION M	18-03-83	340.0	6.0	25.0	GPM	UNK	13	BED	

Annex 4

Organizations Contacted

A. Provincial

1. Newfoundland

Mr. Jim Robinson
Manager, Groundwater Branch
Department of Environment
P.O. Box 4750
100 Elizabeth Avenue
St. John's, Newfoundland
A1C 5T7
Phone: (709) 576-2539

2. Prince Edward Island

Mr. Rory Francis
Head, Water Resources Section
Department of Community & Cultural Affairs
P.O. Box 3000
3 Queen Street
Charlottetown, Prince Edward Island
C1A 7N8
Phone: (902) 892-0311

3. Nova Scotia

Dr. Chang Lin
Chief, Water Resources Planning
Department of Environment
P.O. Box 2107
5151 Terminal Road
Halifax, Nova Scotia
B3J 3B7
Phone: (902) 424-5300

4. New Brunswick

Mr. Ron Brinsmead
Groundwater Branch
Department of Municipal Affairs and Environment
P.O. Box 6000
364 Argyle Street
Fredericton, New Brunswick
E3B 5H1
Phone: (506) 453-2353

5. Quebec

Mr. Colin Bilodeau
Chief, Groundwater Sector
Water Resources Directorate
Ministry of the Environment
3900 Marly Street
4th Floor
Ste. Foy, Quebec
G1X 4E4
Phone: (418) 644-3568

6. Ontario

*Mr. F. Peter McKenna
Co-ordinator, Groundwater Assessment
Drinking Water Section
Water Resources Branch
Ministry of the Environment
Suite 100
135 St. Clair Avenue West
Toronto, Ontario
M4V 1P5
Phone: (416) 965-2105

7. Manitoba

*Mr. L.R. (Lock) Gray
Head, Hydrogeology Section
Water Resources Branch
Department of Natural Resources
1577 Dublin Avenue
Winnipeg, Manitoba
R3E 3J5
Phone: (204) 945-7403

Mr. Erv Griffin
General Manager
Manitoba Water Services Board
P.O. Box 1059
Brandon, Manitoba
R7A 6A3
Phone: (204) 727-5358

8. Saskatchewan

*Mr. Uwe Roeper
Chief, Groundwater Section
Resources Management
Saskatchewan Water Corporation
Victoria Place
111 Fairford Street, East
Moose Jaw, Saskatchewan
S6H 7X5
Phone: (306) 694-3963

*Mr. Martin Wrubleski
Manager, Agricultural Engineering
Department of Agriculture
3085 Albert Street
Regina, Saskatchewan
S4S 0B1
Phone: (306) 787-6587
N.B.: suggested U. Roeper

9. Alberta

Mr. Allan Kerr
Director
Earth Sciences Division
Alberta Environment
14th Floor, Standard Life Centre
10405 Jasper Avenue
Edmonton, Alberta
T5J 3N4
Phone: (403) 427-6180

Mr. Archie Archampong
Agricultural Engineering Services
Alberta Agriculture
7000-113 Street
Edmonton, Alberta
T6H 5T6
Phone: (403) 427-2181

*Mr. Joe Milos
Section Head
Municipal Engineering Branch
Environmental Protection Services
Alberta Environment
9820-106 Street
Edmonton, Alberta
T5K 2J6
Phone: (403) 427-5837

10. British Columbia

*Dr. John C. Foweraker
Head, Groundwater Section
Water Management Branch
Ministry of Environment and Parks
765 Broughton Street
Victoria, British Columbia
V8V 1X5
Phone: (604) 387-1115

*Mr. Bill Bailey
Head
Public Health
Engineering Section
Water Management Branch
765 Broughton Street
Ministry of Environment and Parks
Victoria, British Columbia
V8V 1X5
Phone: (604) 387-1184

11. Yukon Territory

*Mr. R.A. Yaworsky
A/Director
Municipal Engineering Branch
Department of Community and Transportation Services
Yukon Government
P.O. Box 2703
Whitehorse, Yukon
Y1A 2C6
Phone: (403) 667-5811

12. Northwest Territories

*Mr. Vern Christensen
Director, Community Works and Capital Planning
Department of Municipal and Community Affairs
Government of the Northwest Territories
Yellowknife, NWT
X1A 2L9
Phone: (403) 920-8715

B. Federal

1. Environment Canada

*Mr. Gary Grove
Head, Hydrogeology
Ground Water Division
National Hydrology Research Institute
11 Innovation Blvd.
Saskatoon, Saskatchewan
S7N 3H5
Phone: (416) 667-4803

Mr. Hans Martin
LRTAP Coordination Office
Atmospheric Environment Service
Environment Canada
4905 Dufferin Street
Downsview, Ontario
M3H 5T4
Phone: (306) 975-5718

Mr. Frank Vena
Chief
Inventory Management Division
Environmental Protection Program
351 St. Joseph Blvd.
Hull, Quebec
J8Y 3Z5
Phone: (819) 953-1655

*Mr. François Cadoret
Data Officer
Inventory Management Division
Environmental Protection Program
351 St. Joseph Blvd.
Hull, Quebec
J8Y 3Z5
Phone: (819) 953-1655
(answered for F. Vena)

2. Agriculture Canada

*Mr. Bob Wettlaufer
Director, Policy and Analysis Service
P.F.R.A.
Motherwell Bldg.
1901 Victoria Avenue
Regina, Saskatchewan
S4P 0R5
Phone: (306) 780-5082

*Mr. G.G. Pearson
A/Director, Policy and Analysis Services
P.F.R.A.
Motherwell Bldg.
1901 Victoria Avenue
Regina, Saskatchewan
S4P 0R5
Phone: (306) 780-5082
(answered for R. Wettlaufer)

3. Indian and Northern Affairs Canada

*Mr. P. Laporte
Regional Manager
Water Resources Division
Indian & Northern Affairs Canada
Box 1500
Yellowknife, NWT
X1A 2R3
Phone: (403) 920-8110
N.B.: referred us to V. Christensen

4. Atomic Energy of Canada Limited

*Mr. R.W. Pollock
AECL Research Company
275 Slater Street
Ottawa, Ontario
K1A 1E5
Phone: (613) 236-6444

C. Consultants, Researchers and Associations

Dr. John A. Cherry
Institute for Groundwater Research
University of Waterloo
Waterloo, Ontario
N2L 3G1
Phone: (519) 888-4516

Ms. Kathleen Watson
Secretary/Manager
Canadian Water Well Association
Box 7667
Saskatoon, Saskatchewan
S7K 4R4
Phone: (306) 343-1454

*Mr. Kevin McCray
National Water Well Association
6375 Riverside Drive
Dublin, Ohio
USA 43017
Phone: (614) 761-1711

*Mr. R.E.J. Leech
President
International Association of Hydrogeologists
Canadian National Chapter
c/o Gartner Lee Limited
140 Renfrew Drive
Markham, Ontario
L3R 6B3
Phone: (416) 477-8400

* Received answer in time for report

Annex 5

PFRA Support for Water Wells and Precipitation Catchment Systems in Western Canada

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A. Introduction	82
B. Water Wells	82
C. Precipitation Catchment Systems	82

Tables

A5.1	Water Wells Installed Under PFRA Rural Development Program, 1973-1988	83
A5.2	Dugouts Installed Under PFRA Rural Development Program, 1973-1988	85

Note: This annex has been compiled on the basis of information provided by the PFRA headquarters in Regina, including:

a) Publications comprising:
"Prairie Soil, Prairie Water: The PFRA Story"
"Wells for Farm Water Supplies"
"Dugouts for Farm Water Supplies"
"Rural Water Development Program"
b) Statistics from annual reports; and
c) Analysis by PFRA staff

A. Introduction

The Prairie Farm Rehabilitation Administration (PFRA) was created by Parliament in 1935 to deal with the drought and soil-drifting problems affecting a large part of the prairie region. A water development program was begun at that time to help farmers and ranchers conserve water in dugouts and small dams. During the past 50 years, PFRA has continued to give financial and technical assistance to producers throughout the prairies to make secure water sources available for agricultural use.

Over the years, PFRA's water development program has grown and evolved. Small rural communities and groups of farmers are now eligible for assistance with water projects.

The Rural Water Development Program, as it is now known, provides assistance for three types of projects:

(a) Individual on-farm projects

(b) Group projects

(c) Community projects.

Individual On-farm Projects

PFRA provides financial and technical assistance to farmers and ranchers throughout the prairie provinces for the planning and construction of wells, dugouts, dams and irrigation projects.

Upon request, PFRA provides a variety of technical services to farmers to help develop reliable water supplies for domestic, livestock and irrigation uses.

A maximum contribution of $1,650 is provided for water source projects such as wells, dugouts, or dams. In some instances pipelines from the source to the farm yard may also be included. Financial assistance will not exceed one-third of the project costs.

Group and Community Projects

Financial and technical assistance is available to groups of five or more farmers or ranchers for developing water sources for domestic, stock-watering and irrigation use. Similar aid is given to small rural centres (population of 300 or less) for municipal water supplies.

Subject to available resources, PFRA will investigate water development alternatives for groups and communities. Assistance is available for the investigation, planning, survey, design and construction of water projects.

Subject to the availability of funds, PFRA will contribute up to 50% of eligible costs for the development of water supplies for domestic, municipal, livestock and irrigation uses. Eligible projects include wells, dugouts, dams, pipelines, storage tanks, and tank loading facilities.

This annex deals with two types of water supply facilities built with PFRA assistance: water wells and rainwater catchment systems, particularly dugouts, which are often used to provide drinking water for people and collect water primarily from snowmelt. Most of these facilities have been constructed as individual on-farm projects.

B. Water Wells

PFRA has been helping farmers with water wells since 1973. In the decade or so before then, the provincial and federal governments had cooperated to research the groundwater situation in each province. Prior to this work there was only a limited understanding of groundwater sources.

Two types of wells have been built with PFRA assistance. Small diameter wells, generally less than 15 cm in diameter, can be driven or jetted to shallow depths or drilled to deeper depths, using rotary or cable tool equipment. Large diameter wells, usually 76 cm in diameter, are usually bored with a machine-driven auger and cribbed with galvanized steel or fibre glass. These large diameter wells are invariably rather shallow, with depths rarely exceeding 30 m.

Over the past 15 years a total of 73 816 (to December 31, 1987) wells have been assisted. Some 40% of these wells have been large diameter, shallow wells; however in recent years the number of large diameter wells has decreased to about 30%. Over half of those have been installed in Saskatchewan. Table A5.1 lists the numbers of wells constructed in each province by years.

Records of these water wells are provided by the drillers to the relevant provincial authorities.

A 1971 survey done by PFRA showed that 75% of farms on the prairies depend on wells for household water.

PFRA officials estimate that approximately 70% of wells from 1983 to present were used for household use for the farm population.

C. Precipitation Catchment Systems

Dugouts were initially designed by PFRA to overcome drought problems by catching snowmelt run-off during spring to supply water for a farm family's use, the irrigation of a garden and the needs of 25 head of livestock. About 14 000 dugouts had been completed within the first six years of PFRA's program.

Between 1935 and 1987 PFRA helped construct approximately 115 000 dugouts: 55.1% in Saskatchewan, 26.1% in Alberta and 18.8% in Manitoba. Table A5.2 provides details.

Many of these dugouts, particularly the ones built before groundwater conditions were clearly understood, intercept the water table. In a sense, therefore, such dugouts capture both ground water and surface water.

Approximately 15% of projects identified as household or household and livestock use, are dugouts.

Present design procedures for dugouts, outlined in the PFRA publication "Dugouts for Farm Water Supplies", consider the annual consumption required for humans, livestock and small scale irrigation. The dugout volume, which depends on required water consumption and the climate in which it will be built, usually averages between 3000 m^3 and 4000 m^3 for livestock use whereas dugouts for year-round household and livestock use would likely be greater than 5000 m^3 to 6000 m^3.

Table A5.1
Water Wells Installed Under PFRA Rural Development Program, 1973-1988*

Province and Year	Small Diameter Wells		Large Diameter Wells	
	Number	Average Depth(m)	Number	Average Depth(m)
Alberta				
1973-1974	1 343	52.1	321	13.2
1974-1975	2 420	51.1	583	13.9
1975-1976	1 862	49.7	481	15.0
1976-1977	2 096	51.1	560	15.8
1977-1978	2 439	52.9	674	14.1
1978-1979	1 554	51.7	475	15.9
1979-1980	1 678	52.2	439	16.0
1980-1981	2 181	56.8	516	17.7
1981-1982	2 061	53.9	586	13.8
1982-1983	1 800	52.6	476	17.1
1983-1984	1 660	48.1	406	17.3
1984-1985	1 832	49.3	387	16.5
1985-1986	2 030	54.1	386	16.9
1986-1987**	2 001	55.4	383	17.2
1987-1988**	1 061	52.6	191	16.4
Sub-Total	28 018		6 864	
Saskatchewan				
1973-1974	812	50.6	719	13.4
1974-1975	863	56.8	1 081	13.8
1975-1976	719	59.6	978	12.9
1976-1977	747	58.5	1 250	13.1
1977-1978	846	64.9	1 550	13.3
1978-1979	506	56.9	1 074	13.6
1979-1980	597	55.4	1 065	13.6
1980-1981	827	62.9	1 527	14.0
1981-1982	848	73.6	1 633	13.2
1982-1983	610	62.9	997	13.6
1983-1984	543	55.6	835	14.2
1984-1985	647	64.5	758	14.0
1985-1986	448	61.2	578	14.5
1986-1987**	532	57.3	570	14.3
1987-1988**	437	60.2	491	14.4
Sub-Total	9 982		15 196	

Table A5.1
Water Wells Installed Under PFRA Rural Development Program, 1973-1988* (Cont'd)

Province and Year	Small Diameter Wells		Large Diameter Wells	
	Number	Average Depth(m)	Number	Average Depth(m)
Manitoba				
1973-1974	621	35.2	549	13.7
1974-1975	765	36.5	619	14.5
1975-1976	686	40.9	609	9.1
1976-1977	700	36.1	638	9.2
1977-1978	774	35.2	526	9.4
1978-1979	507	36.1	329	10.3
1979-1980	522	37.5	289	10.2
1980-1981	646	36.9	478	10.7
1981-1982	461	38.6	409	10.7
1982-1983	435	36.5	358	10.4
1983-1984	473	37.5	321	10.4
1984-1985	440	37.2	338	11.3
1985-1986	288	36.9	135	11.5
1986-1987**	317	40.1	148	10.5
1987-1988**	330	40.4	135	10.1
Sub-Total	7 965		5 881	
Total	45 965		27 851	

* Data ends on December 31, 1987.

** Data includes previously reported wells having received supplementary assistance which inflates figures by about 1% (P.J. Wettlaufer).

PFRA officials estimate that likely 50% of these dugouts are still in active use (the rest having been silted-up or otherwise become disused) and that perhaps 30% of the active dugouts are used to supply drinking water to an estimated 70 000 people throughout the prairie provinces. (This estimate is derived by assuming that the total farm population of the three provinces (Manitoba, Saskatchewan and Alberta) in 1981 was 480 822 and that 15% of farms use dugouts as a household source; therefore, a simple calculation (15% of 480 822 gives 72 123) gives the previous estimate.) (Our estimate, from the 1981 farm population of Table 1.3 gives about 67 000 (15% of 447 493) people.)

Table A5.2
Dugouts Installed Under PFRA Water Development Program, 1935-1988

Year	Alberta	Saskatchewan	Manitoba	Total
1935-1962	9 585	43 006	14 439	67 030
1962-1963	1 252	4 036	989	6 277
1963-1964	1 562	1 416	447	3 425
1964-1965	1 074	1 670	460	3 204
1965-1966	631	785	280	1 696
1966-1967	711	751	183	1 645
1967-1968	1 387	1 175	667	3 229
1968-1969	343	498	172	1 013
1969-1970	380	334	128	842
1970-1971	392	298	162	852
1971-1972	376	536	130	1 042
1972-1973	490	761	232	1 483
1973-1974	852	1 082	557	2 491
1974-1975	813	606	299	1 718
1975-1976	673	373	224	1 270
1976-1977	523	429	214	1 166
1977-1978	794	798	307	1 899
1978-1979	419	410	129	958
1979-1980	498	448	129	1 075
1980-1981	643	688	315	1 646
1981-1982	824	1 140	310	2 274
1982-1983	598	455	169	1 222
1983-1984	652	316	163	1 131
1984-1985	633	531	218	1 382
1985-1986	1 319	328	81	1 728
1986-1987	2 208	341	78	2 627
1987-1988	563	673	116	1 352
Sub-Total	29 982	63 330	21 561	114 873

* Data up to December 31, 1987.

Annex 6

Maps

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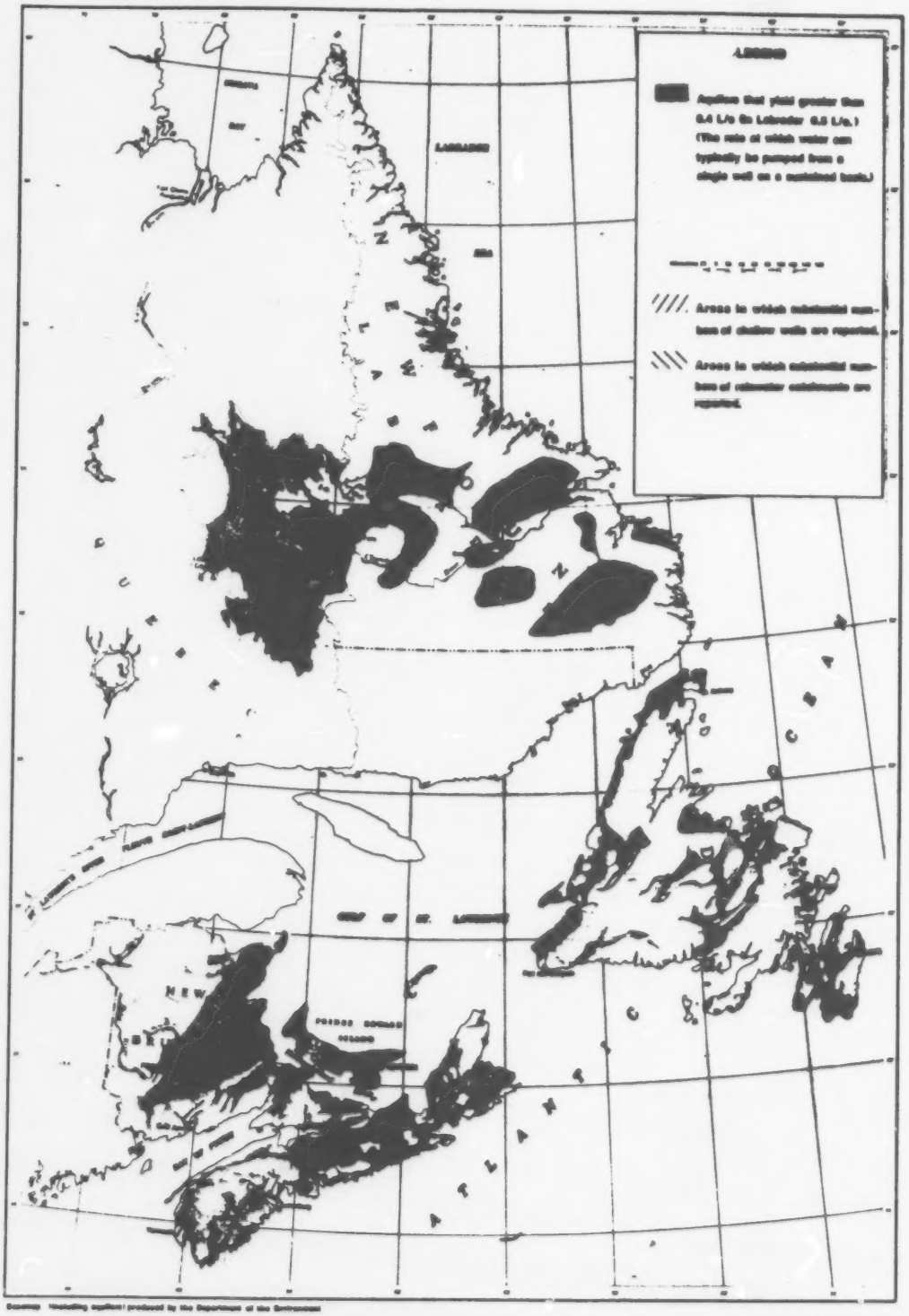
MAP No. 1

AQUIFERS AND AREAS OF SHALLOW WELL AND RAINWATER CATCHMENT USE

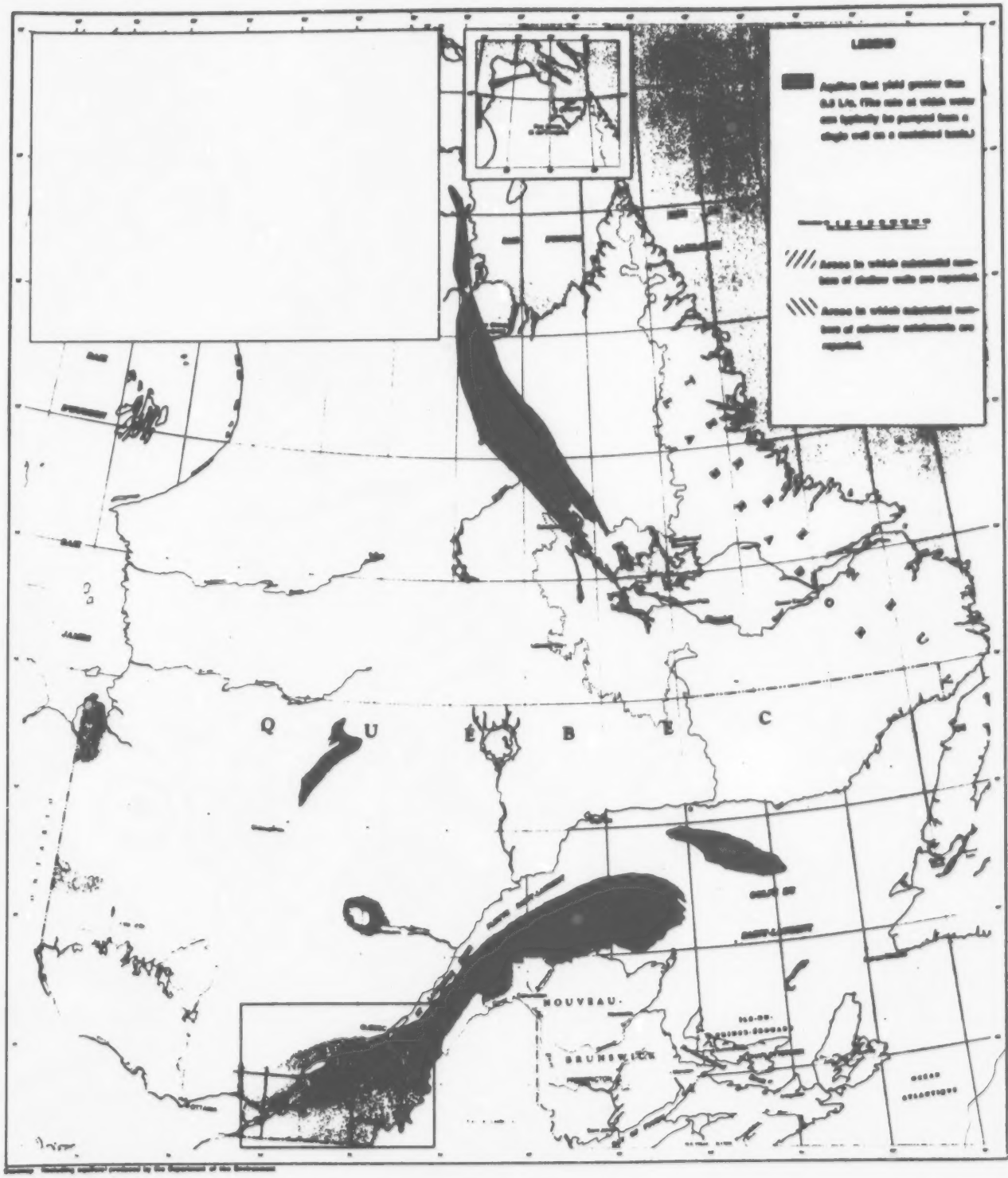
ATLANTIC REGION



MAP NO. 2

AQUIFERS AND AREAS OF SHALLOW WELL AND RAINWATER CATCHMENT USE

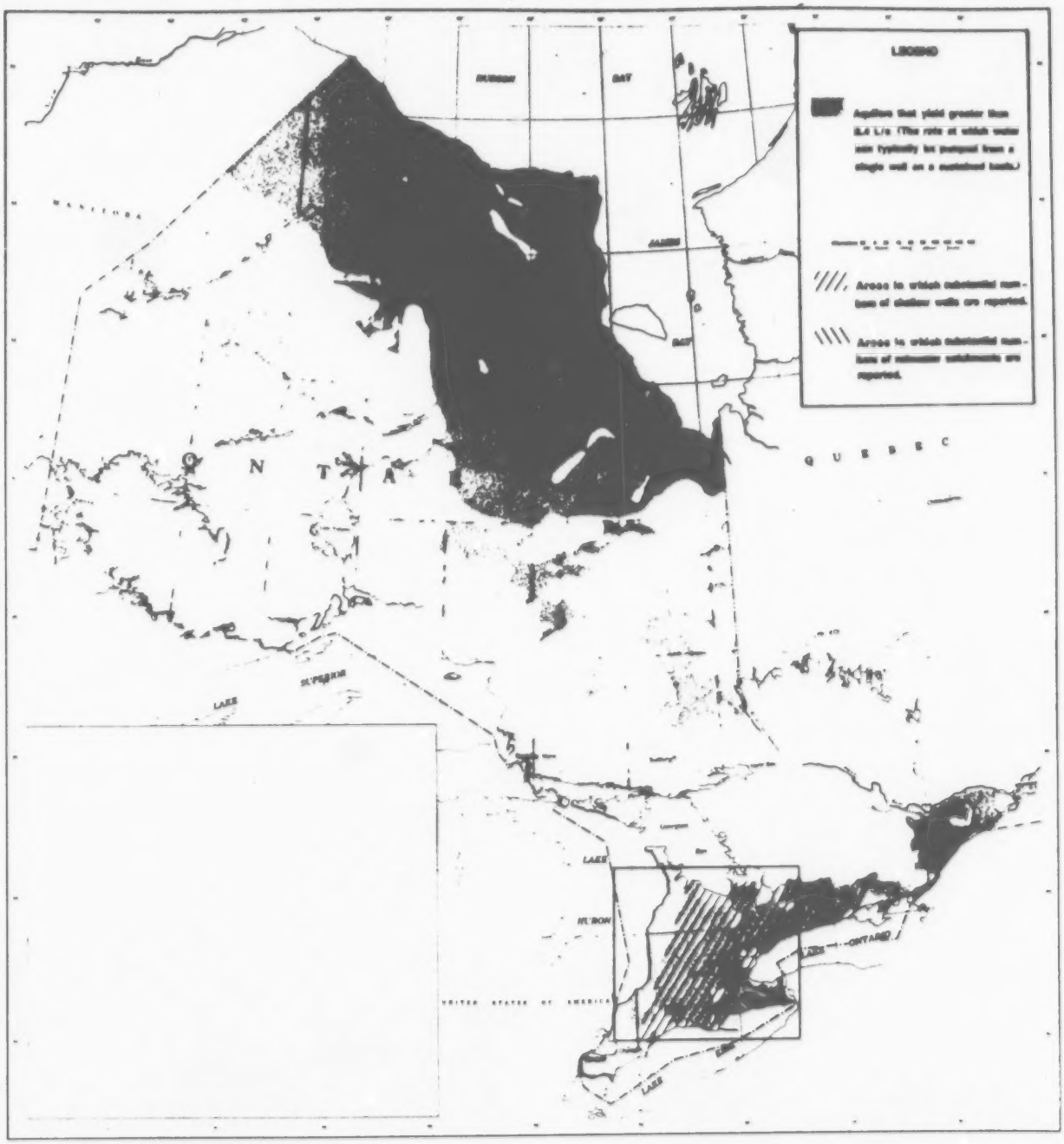
QUEBEC REGION


LEGEND
Aquifers that yield greater than 0.5 l/s. This rate at which water can typically be pumped from a single well on a sustained basis.
Areas in which substantial numbers of shallow wells are reported.
Areas in which substantial numbers of rainwater catchments are reported.
Q U É B E C
NOUVEAU-
BRUNSWICK

MAP No. 3

AQUIFERS AND AREAS OF SHALLOW WELL AND RAINWATER CATCHMENT USE

ONTARIO REGION

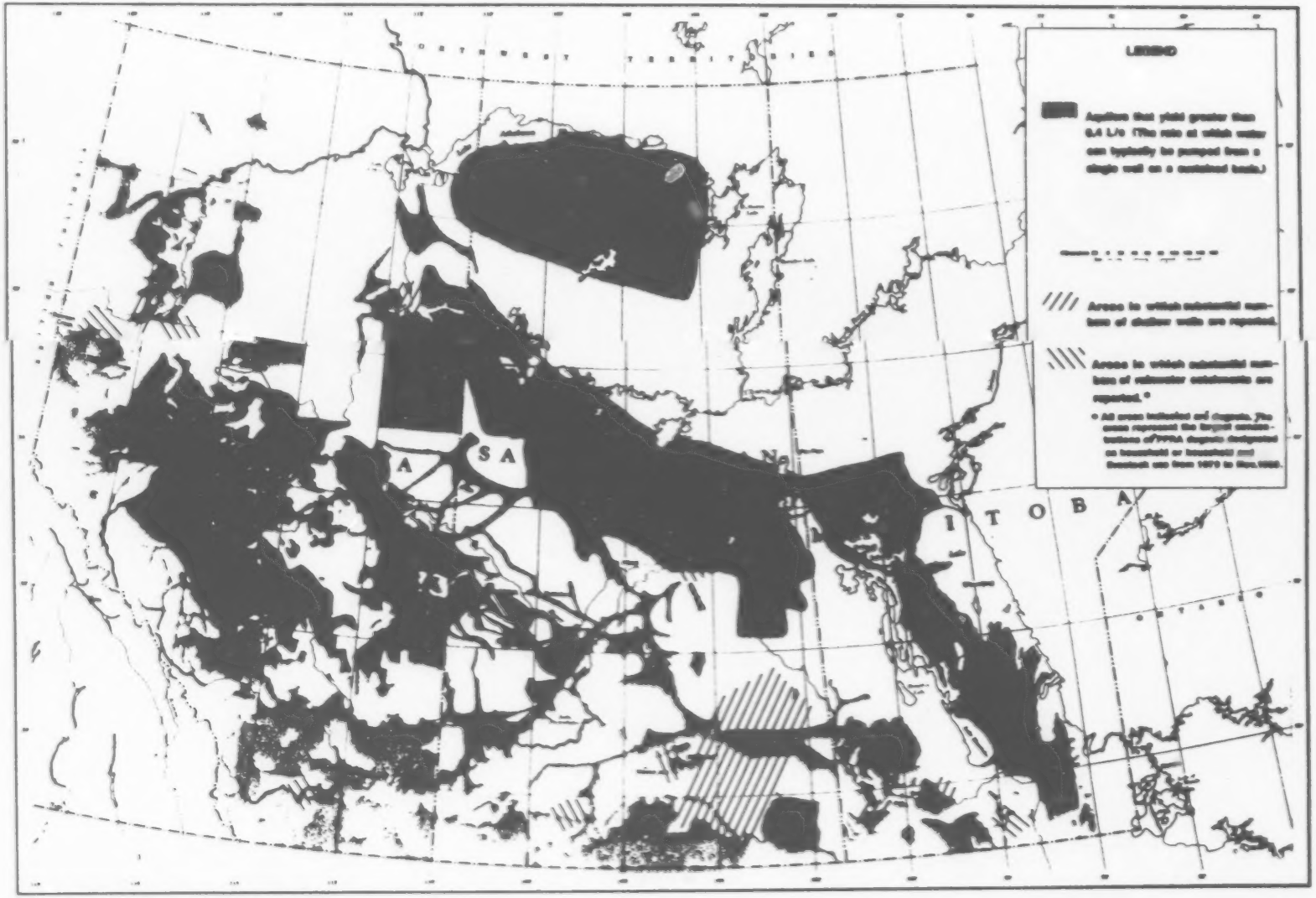

LEGEND
Aquifers that yield greater than (L/s L/s. (The rate at which water can typically be pumped from a single well on a sustained basis.)
Areas in which substantial numbers of shallow wells are reported.
Areas in which substantial numbers of rainwater catchments are reported.
ONTARIO
QUEBEC
LAKE
HURON
UNITED STATES OF AMERICA

Sources: ... including aquifers produced by the Department of the Environment

MAP No. 4

AQUIFERS AND AREAS OF SHALLOW WELL AND RAINWATER CATCHMENT USE

PRAIRIE REGION

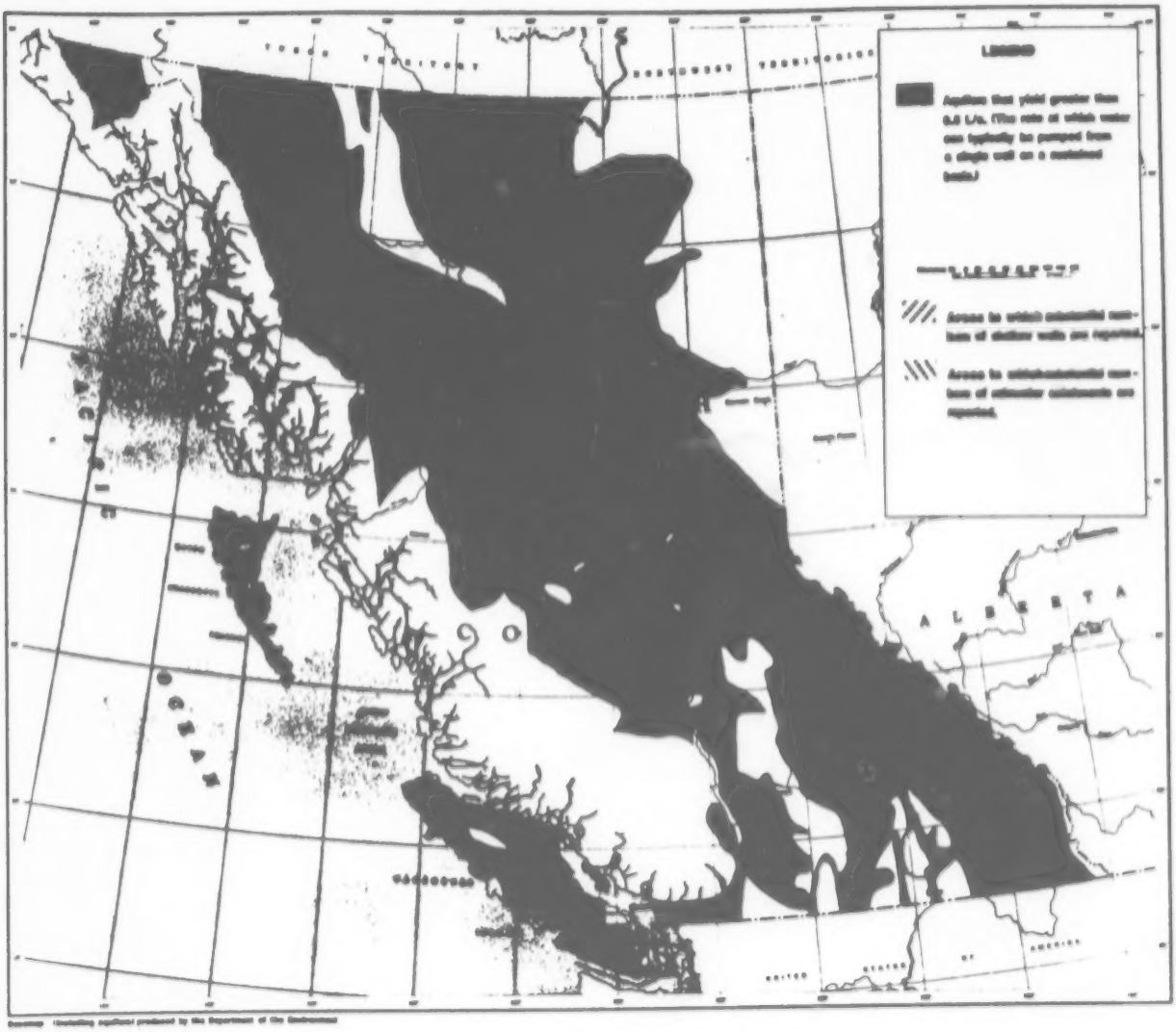


Courtesy - (including aquifers) produced by the Department of the Environment

MAP No. 6

ACQUIFERS AND AREAS OF SHALLOW WELL AND RAINWATER CATCHMENT USE

BRITISH COLUMBIA REGION

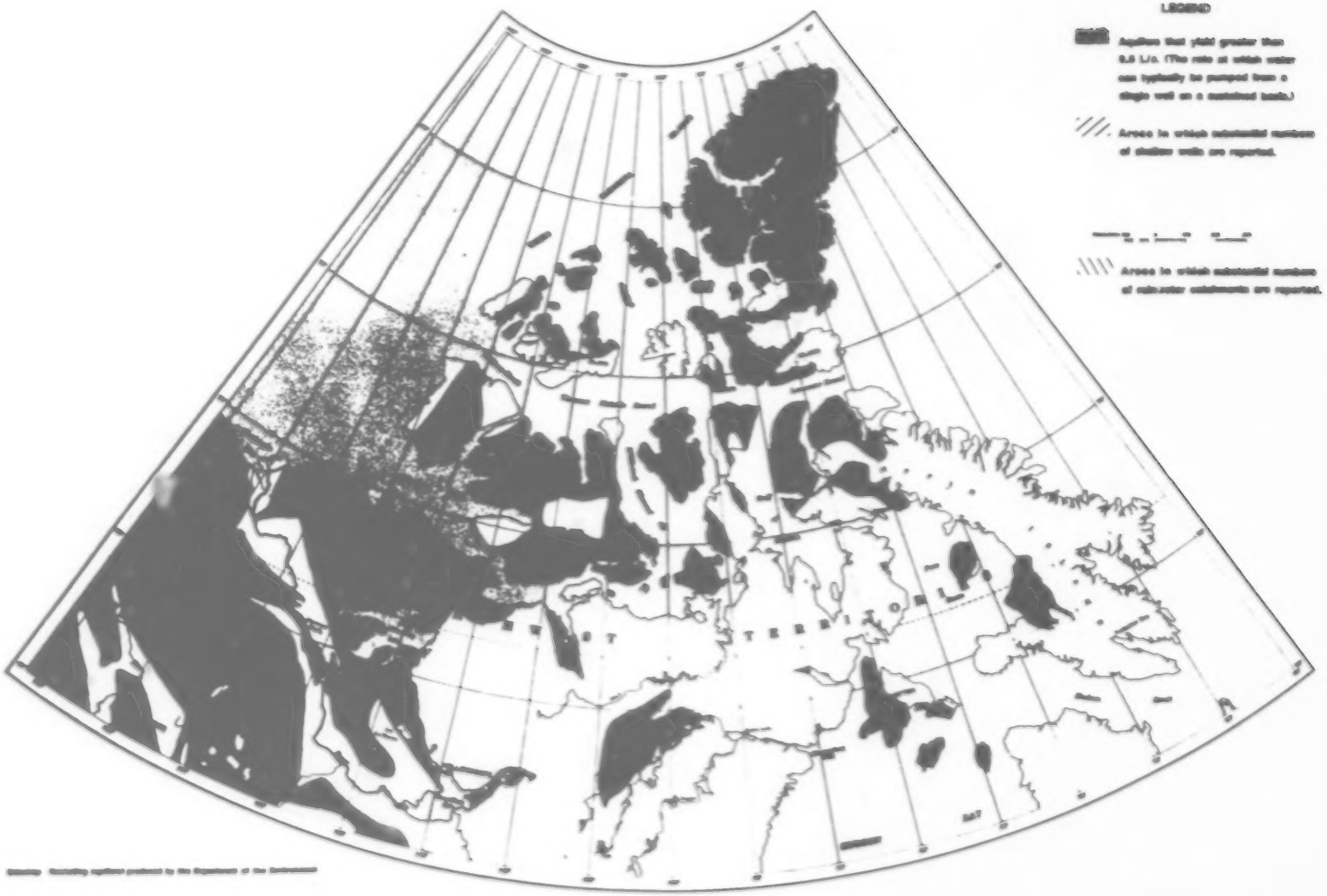


Geology (including aquifers) produced by the Department of the Environment

MAP No. 6

AQUIFERS AND AREAS OF SHALLOW WELL AND RAINWATER CATCHMENT USE

NORTH OF 60° REGION


LEGEND
Aquifers that yield greater than 0.5 L/s. (The rate at which water can typically be pumped from a single well on a sustained basis.)
Areas in which substantial numbers of shallow wells are reported.
Areas in which substantial numbers of rainwater catchments are reported.

Source: Hydrology synthesis produced by the Department of the Environment